Value Engineering
and
its Application in the Construction Industry

by

Panagiota E. Paraoulaki

B.S., Rural and Surveying Engineering (1999)

National Technical University of Athens, Greece

Submitted to the Department of Civil and Environmental Engineering
in Partial Fulfillment of the Requirements for the Degree of

Master Of Engineering
in Civil and Environmental Engineering

at the

Massachusetts Institute of Technology

June 2000

Signature of the Author.....
Department of Civil and Environmental Engineering
May 5, 2000

Certified by.....
John B. Miller
Professor of Civil and Environmental Engineering
Thesis Supervisor

Accepted by.....
Daniele Veneziano
Chairman, Departmental Committee on Graduate Studies

VALUE ENGINEERING
AND
ITS APPLICATION IN THE CONSTRUCTION INDUSTRY

by

Panagiota E. Paraoulaki

Submitted to the Department of Civil and Environmental Engineering

On May 5, 2000 in partial fulfillment of the

Requirements for the Degree of Master of Engineering in

Civil and Environmental Engineering

ABSTRACT

The purpose of this thesis is to analyze value engineering and evaluate its application on construction projects. The evolution and spreading of value engineering are described and the methods used to implement it are analyzed.

The purpose of its application in the construction industry is identified and the benefits that follow its implementation during the several phases of a construction project are evaluated.

The successful results of its implementation are illustrated through the analysis of the value engineering efforts that took place during the several stages of design of the Regional Transportation Center, Woburn, Massachusetts.

Thesis Supervisor: John B. Miller

Title: Professor of Civil and Environmental Engineering

Acknowledgments

First, I would like to express my gratitude to Professor John B. Miller, for his enthusiasm and encouragement during this thesis. I am extremely grateful to him for the endless help and support he has given to me. His advice has always been invaluable.

Next, I would like to thank Mr. Christopher M. Gordon, Capital Programs Director, Massachusetts Port Authority and Mr. Kenneth F. Johnson, Program Manager, Massachusetts Port Authority for the information and the valuable knowledge that they have offered me.

Finally, I would like to thank my family and friends in Greece for believing and supporting me. It is indeed a blessing to have them all emotionally so close to me. Their unconditional love, emotional support and encouragement have always been a driving force for me to pursue my goals and fulfill my dreams. I would also like to thank my brother Ioannis for his endless help and love, and my friend Petros for his constant support during my stay at MIT.

Finally, it is difficult to find words to express my love and gratitude to my parents, Emmanouil and Dimitra, to whom I dedicate this thesis. Their love, encouragement, and understanding have always been a constant source of motivation, and strength for me. They deserve special thanks for their patience and all the sacrifices that they have made for me in the last 24 years. A lifetime may be a too short time to give them as much as they have given me.

Panagiota E. Paraoulaki
Cambridge, Massachusetts
May, 2000

Αφιερωμένη στους γονείς μου

Table of Contents

PART A. Value Engineering

1. Introduction 9

2. History and Evolution of VE 12

3. VE' s Philosophy 18

3.1. Definition and Terminology 18

3.2. VE versus Cost Reduction 20

4. Methodology 23

4.1. Functional Analysis System Technique (FAST) 23

4.2. The Job Plan 27

4.2.1. The Information phase 28

4.2.2. The Speculation phase 29

4.2.3. The Analytical phase 29

4.2.4. The Development phase 30

4.2.5. The Presentation phase 31

PART B. Application in the Construction Industry

5. VE in the Construction Industry 32

5.1. Characteristics of the Construction Industry 32

5.2. Purpose of Applying VE in the Construction Industry 34

5.3. The Application of the Job Plan in Construction Projects 35

5.4. Potential Savings versus Time 36

5.5. VE during the Several Phases of a Construction Project 38

5.5.1. VE during the Conceptual Design 38

5.5.2. VE during the Design Phase 38

5.5.3. VE during the Construction Phase 39

6. Case Study: "Regional Transportation Center, Woburn, Massachusetts" 42

6.1. Description of the Project 42

6.2. The Purpose of the VE Study 43

6.3. VE during the Preliminary Design 43

6.4. VE at 30% of Design 46

6.5. VE at 60% of Design 46

6.6. Conclusion 47

7. Conclusions and Recommendations 49

8. Bibliography - References 52

9. Appendix A 55

10. Appendix B 65

11. Appendix C 72

12. Appendix D 83

13. Appendix E 105

14. Appendix F 119

List of Figures

Figure 4.1. Functional Analysis System Technique (FAST) diagram
Figure 4.2. The Job Plan phases
Figure 5.1. Decision – makers' influence on cost
Figure 5.2. VE Savings during Life of a Construction Project
Figure 6.1. Cost estimate vs % of completion of design

List of Tables

Table 5.1. Percentage of savings awarded to a contractor

PART A. VALUE ENGINEERING

1. Introduction

Value engineering was originally conceived by Lawrence D. Miles (1961) as a set of techniques for achieving better value in hardware programs, through modification of the design, manufacturing techniques, or improved procurement methods. Miles anticipated the need for a system like value engineering and developed it before the need actually became apparent, and then made it available when its need became obvious, during the late fifties. In his book "Techniques of Value Analysis and Engineering" (1961), he states that: "value engineering –or value analysis- is a problem-solving system implemented by the use of a specific set of techniques, a body of knowledge, and a group of learned skills. It is an organized creative approach that has for its purpose the efficient identification of unnecessary cost".

This problem-solving system can be applied either to products or services. When applied to products, it usually refers to alternative materials, newer processes, and abilities of specialized suppliers. It

focuses its attention on one objective: how to achieve equivalent performance for lower cost. Having this focus, it provides several procedures for accomplishing its objectives with efficiency and assurance. On the other hand, when applied to services, it refers to a thorough collection and penetrating analysis of information surrounding the service, viable alternatives from the creative mental processes, and development of better approaches that minimize disadvantages and maximize advantages sufficiently to meet the need for cost and operation improvement.

In addition to the numerous applications and developments within value engineering itself, much greater emphasis has been placed upon cost reduction. During the last decades it had been increasingly apparent that there was a need for an integrated treatment of value engineering and its interrelationships with cost reduction techniques. This is particularly true, especially in the areas of management and of the application of value engineering to nonhardware projects, where the need for coverage of management of value programs, contractual and subcontractual arrangements, cost target programs, and application of value engineering to systems and procedures, is always increasing.

However, there is an inevitable impression that value engineering is suitable only for large firms with high turnovers, and not for small firms with correspondingly small turnovers. In fact, this is not true: the need to save money applies equally well to both large and small firms. Raven, in his book "Profit Improvement by Value Analysis, Value Engineering and Purchase Price Analysis" (1971) mentions the following: "It is more likely that a large firm with high output will have assessed its tooling in a detailed manner, the production processes will therefore be fairly sophisticated. Because of this sophistication, the saving per component will probably be fairly small, and require considerable effort to achieve. With a high turnover of components,

even a small saving on each could amount to a substantial sum of money. On the other hand, the small firm with a much smaller production is likely to have less sophisticated techniques. The cost per component will probably be correspondingly higher and the savings will be easier to obtain, because the changes required will not be so radical".

Nowadays, and despite its importance, value engineering, as a field of study, is still fledging. As a profession, compared to other long-established engineering disciplines, such as civil engineering, mechanical and electrical engineering, value engineering is relatively young. According to Patrick Sik Wah Fong (1997), value engineering is very different from all the other engineering disciplines; it does not have a clear body of knowledge, there is no unified approach in applying it, and most significantly it is considered as both a science and an art.

2. History and Evolution of Value Engineering

In 1938, Lawrence D. Miles, a design engineer for the General Electric Company (GE) in Schenectady, New York, was very concerned with the way that things were going at the plant and went to see his supervisor in order to express his concern about the fact that nobody cared about what things cost in the plant. His supervisor, W. C. White, immediately called H. Erlicher, who was the Vice President of Purchasing and Traffic, and related the incident. This prompted Erlicher to confer with Miles and reassign him to Central Purchasing, directly under his supervision (Modeco C. M., 1978).

Two years later, when World War II broke out in Europe, the U.S. industry started facing a unique challenge, for which it was not prepared. The paramount objective throughout the nation was now the production of war materials instead of commercial goods. This transition from commercial goods to war materials changed completely the character of the industry.

At this point, Miles was assigned the task of finding, negotiating for and getting a number of vital materials, such as copper, bronze, tin, nickel and electrical resistors, and use them to expand the production of turbo-superchargers from 50 per week to 1000 per week. At the same time, suppliers, who already overextended, had no intention to increase their production schedules or manufacture new products. In this desperate and unpleasant situation, Miles thought that "if he could not get the product, he had to get the function". The next step was to rush all the engineering tests and the required approvals and so the desired production rates and schedules were met. By this way "function" grew in vitality and the basis for the later development of value analysis -or value engineering- was already established.

After World War II was over, several executives of the General Electric Company recognized in retrospect that a number of substitutions, enforced by wartime shortages of strategic materials, had resulted in products which were as good as the original ones, but which cost less. The primary purpose of these substitutions, of course, was not cost reduction; but these executives reasoned that if cost reduction could be the inadvertent result of material substitutions, it should be possible to develop methods and techniques that would create this result deliberately. Therefore, and due to his previous experience, Lawrence D. Miles was chosen in 1947 to develop a set of techniques that, through material substitutions and changes in manufacturing techniques and design, could result in substantial reductions in cost.

Over the next several years, a set of methods and techniques were developed around the idea that concentration on function rather than products yields more dramatic and productive results, and the concept of value was approached in a more systematic and scientific way. By the end of 1951 these methods and techniques where successfully applied on a number of real products. It was then realized

that sufficient knowledge in value engineering existed and it was decided that these techniques should be taught in a formal training environment. The name chosen for these methods and techniques was "value analysis" –which is still in use today-, and the first "value analysis seminar" was conducted in 1952 and lasted four weeks (Heller D. E., 1971).

Over the next two years, interest in value engineering grew. Relevant articles began to appear in trade journals and several companies began to exploit the techniques. The first to initiate training and establish a formal VE program was the Navy Bureau of Ships. In 1954 the Navy Bureau of Ships recognized the value of these techniques and established a formal organization under the name of "value engineering". The aim of this organization was to save $35 million from the Navy's engineering design applications.

Miles had been in a purchasing function at the time of his assignment to value analysis. Through his association, one of the first organizations to promote and publicize value engineering was the National Association of Purchasing Agents. This attempt was fully supported by the Electronics Industries Association (EIA). In 1958 the first Value Engineering Subcommittee was formed under Admiral R. S. Mandelkorn, who was formerly associated with the value engineering program in the Navy Bureau of Ships. A keen interest was very quickly developed in this group. Its meetings had greater attendance than almost any other EIA committee and so the subcommittee soon became a committee.

In 1959 the EIA committee held its first conference on value engineering at the University of Pennsylvania in Philadelphia. Three hundred people attended. In 1960 the second national conference on value engineering was held again by the EIA committee, but this time in Anaheim, California. Much of the credit for the rapid expansion of

interest in value engineering in the United States, during the period 1958-1962, must be given to this EIA committee.

During the first national conference conducted by the value engineering committee, the subject of a professional or technical society was broached. This society was named "Society of American Value Engineers" (SAVE) and it was incorporated in Washington D.C., on 22 October 1959. As one of the functions taken over from the EIA committee, the Society of American Value Engineers has conducted an annual national conference every year since 1963. SAVE decided to publish a journal, named "Journal of Value Engineering". This journal was first published in 1962, but unfortunately after a while and due to financial difficulties its publication was suspended. The SAVE committee reinstituted this journal's publication in 1968, and in addition to that they started publishing a monthly newsletter, named "SAVE Communications". But despite the difficulties and problems that this society had to face during the first years, it has grown at an increasing rate and ten years after it was founded it had over 2000 members and over thirty chapters throughout the United States (Heller, 1971).

At the same time (1958) and due to the successful results from the application of value engineering in the Navy Bureau of Ships projects, the Army announced official recognition of the VA program. In the months that followed, hundreds of specialists received formal value engineering training and hundreds of projects demonstrated worthwhile savings. The Army was well on its way with a viable value engineering effort, but at that moment all these efforts had been mostly in-house with very little extension into the private contractors' efforts. Later the Army began to investigate VE possibilities in the private contractor field, but the VE clauses that had been developed were not too well understood and required a concerted selling job with the defense industry. As a result of that the Army began to organize and better equip itself in order to expand the function of value engineering in-

house. The full-time value engineering personnel was increased, but only in the areas of procurement and production. In 1965, Army savings due to VE effort were approaching the $200 million mark and it was now obvious that value engineering had proven itself as an effective management tool for reducing costs and improving the value of Army materiel.

On the other hand, the Air Force did not provide for value engineering in its contracts until 1960, and then only at the discretion of the contracting officer. This situation changed in 1962 and gave way to the present mandatory provision.

In 1963, a very significant action was taken within the department of Defense. The Armed Services Procurement Regulation (ASPR) committee reviewed the results of the value engineering's applications and drafted the first comprehensive treatment of value engineering. It was made mandatory that value engineering should be included in all federal procurements exceeding $100,000 and that VE program requirements should be included in all cost-plus-fixed-fee contracts exceeding $1 million.

The years that followed, others, outside of the Department of Defense, started implementing it to their own projects. The first to do that was the Department of Interior, Bureau of Reclamation. In 1965 they began an intensive program in value engineering for their entire engineering staff; and in 1966 they started placing a VE clause in all their construction contracts. In 1967, the Post Office Department, Bureau of Research and Engineering, instituted a formal VE training program; and in 1969 the National Aeronautics and Space Administration, Office of Facilities did the same.

In 1970, the Federal Register published the first incentive clause to be used by all agencies of the Department of Transportation. The same year, the General Services Administration, Public Buildings Service, published a report that recommended the establishment of a

value engineering program, and so the agency staffed its first full-time value engineer to implement a formal program.

But despite the fact that value engineering has existed for some considerable time -as described above-, it is still in progress. During the past three decades it has undergone a rapid growth and it has increased in scope and importance. Nowadays, and regardless of the fact that VE's application varies widely from organization to organization and from industry to industry, the whole market is recognizing it as a very important element of every project.

3. VE's Philosophy

3.1. Definition and Terminology

The first definition ever used to determine the meaning of value engineering was the following: "Value Engineering/Value Analysis is an organized, creative approach which has for its purpose the efficient identification of unnecessary costs, i.e., costs which provide neither quality nor use nor life nor appearance nor customer features" (Miles, 1961).

But ever since the Navy Bureau of Ships adopted the term "value engineering" there has been a problem with the terminology. Both the EIA Value Engineering Committee and the Society of American Value Engineers (SAVE) have not discouraged the use of the earlier term, "value analysis". The existence and the continuous use of both the terms of "value analysis" and "value engineering" caused confusion to many in the field. People who where involved in

the purchasing function felt that the use of the word "engineering" required that practitioners should have engineering degrees.

At the same time many practitioners in the field wanted to emphasize the fact that the methods and techniques that L. D. Miles had developed could be applied in two faces of a project or program; early in a program, but before completion of the engineering phase, and later, during the manufacturing, production or construction phase. Based on that they decided to use the term "value engineering" in order to designate value work applied during the engineering phase, and "value analysis" for any subsequent value work. Although this separation seemed to be good, it created more confusion in the field of value engineering. The way that both terms where used implied that there was a difference in the techniques or the way in which they were applied during the different phases of a project. It is definitely true that effective value work in the engineering phase requires extensive and thorough engineering knowledge, but that does not mean that value techniques change during the different project phases. In fact, the value methods and techniques are still the same and they should be applied in the same manner in every phase of a project or program.

Since the need for emphasizing both the "before the fact" and the "after the fact" value work existed, and since the phase distinction between value engineering and value analysis was not a desirable one, E. D. Heller decided to introduce the terms of "value assurance" and "value improvement" in order to designate these two phases. According to his definitions, value assurance introduces principles of value into the original concept of a project or program, whatever its nature is, in order to assure value, while value improvement applies the same principles to tasks already accomplished in order to improve value. But despite the fact that these two new terms could solve the problem of the phase distinction, they were not widely spread and nowadays their use is very limited.

Finally, and after some years of argument and disagreement, both the EIA Committee and the Society of American Value Engineers decided on the following definition: "Value engineering is the systematic application of recognized techniques which identify the function of a product or service, establish a value for that function, and provide the necessary functional reliability at the lowest overall cost. In all instances, the required function should be achieved at the lowest life-cycle cost consistent with requirements and/or performance, maintainability, safety and aesthetics". To this definition was added the statement that "Value analysis is considered synonymous with value engineering".

Later, the American Association of Cost Engineers International (AACEI) provided the following definition: "Value engineering or value analysis is a multi-discipline, systematic and proactive function that is targeted at the design itself. The objective is to use value engineering to develop a facility or item design that will yield the least life-cycle cost or provide the greatest value while also meeting all functional, safety, quality, operability, maintainability, durability and other criteria established for it".

These two last definitions remain the definitions that are most commonly used. They are complete and useful ones and give a reasonable conception of value engineering.

3.2. VE versus Cost Reduction

Apart from the confusion that has been created in the field of value engineering about the terminology, there has been a greater one between value engineering and cost reduction. Value engineering is not a substitute for, nor is it intended to replace, effective cost reduction techniques which have been in use for many years.

Normal cost reduction techniques attempt to reduce the cost of a product, without considering the performance or the quality of this product. On the other hand, the value engineering approach attempts to find the lower cost way to perform the desired function, rather then the lower cost way of producing a product.

The fundamental difference between value engineering and cost reduction techniques is that value engineering is function-oriented, while all the other techniques are method-oriented. Some of the mostly used reduction techniques are the work study, the method study and the group capacity assessment. While, for example, method study looks at a particular construction operation, and work study at the ways of assembling components, value engineering examines the cost of these functions, of which construction or assembling are a part. Furthermore, value analysis is by no means simply a search for new materials and processes; that is a search upon which manufacturing concerns and engineering laboratories are constantly engaged. It is not a mere substitute for cost reduction activities that are being carried out by manufacturing or construction organizations.

Apart from that, at the end of the value engineering process we may end up with an entirely different product, which has the same performance or a better one then the original product. Of course, that does not mean that all engineering studies will result in products that look fundamentally different from the original. Moreover, the results of a value analysis effort are generally indistinguishable from those of normal cost reduction. Except in those few cases where the result of a value engineering approach is a completely different unit or product, it is impossible to say, upon examining the results of a product cost-improvement, whether or not value engineering techniques were used.

The conclusion of all the above is that value engineering looks at all the aspects of a process or a product in an attempt to produce this process or product at the lowest price without reduction of neither the

quality or the performance. It is an analytical technique, designed to examine all the facets of cost and function of a unit, in order to determine whether or not any item of cost can be reduced or eliminated, while retaining all functional, performance and quality requirements. At last, in contrast with all the cost reduction techniques, it examines the cost of the function, instead of the component with its appropriate cost.

4. Methodology

4.1. Functional Analysis System Technique (FAST)

The Functional Analysis System Technique (FAST) was developed in 1964, by Charles W. Bytheway, Value Engineering and Cost Reduction Administrator for UNIVAC, Salt Lake City. The purpose of this technique was to show the specific relationships of all functions with respect to others, test the validity of the functions, and so finally enhance the functional analysis effort of the value engineering study.

FAST is a method of analyzing, organizing, and recording the functions of systems, products, plans, processes and procedures. It stimulates organized thinking about any subject by asking thought-provoking questions. In these questions the subject is expressed by using a verb and a noun. In value engineering terms, this noun and verb combination together with an occasional modifier is called a function. The questions asked about each function are: "Why is this function performed?", "How is this function accomplished?", and "When

is this function performed?" (L. D. Miles, 1961). The answers of these questions are arranged in a unique manner relative to each other on a diagram, which is called a FAST diagram.

All the parts and components of a Functional Analysis System Technique diagram are shown in figure 4.1, and the necessary steps to construct it are described in the following paragraphs.

The construction of the FAST diagram starts by asking the question "how?". In this way all the functions of a system are identified and the highest level function is determined. The higher level function is a function that appears to the left of another function in the FAST diagram. The highest level function -or the basic function, as it is called- is placed on the very left of the diagram and it represents the purpose of the subject under study. The chart that is established by identifying and determining all the functions of a system, indicates that all functions answering "how?" questions fall to the right of the function questioned.

By placing all these functions on the FAST diagram a row of functions is created, which is called the critical path (Modeco C. M., 1978). Any function that describes how or why another function is performed belongs to the critical path and thus is called critical path function.

The next step is to ask the question "Why?". The answer to the question why is a specific function performed, should be the same as the function located at its left. This question should be repeated until all critical path functions are verified.

As soon as the critical path is checked the supporting functions should be identified. As supporting functions are considered all the functions that assist a critical path function in doing its job in a reliable manner. These functions are also placed in the FAST diagram, in such a way that the ones that happen "all the time" are above the critical path and the ones that happen "at the same time" and/or "are caused

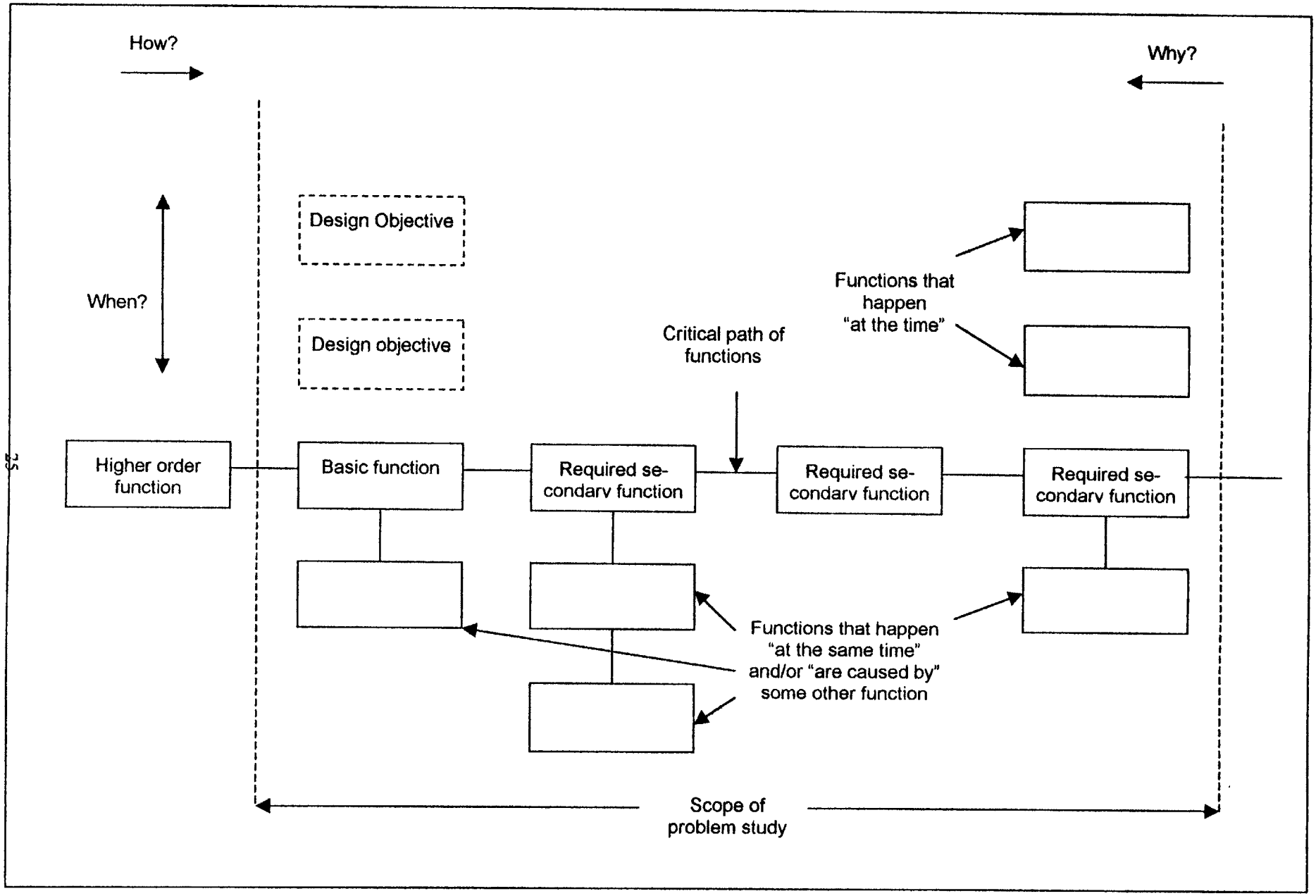


Figure 4.1. Functional Analysis System Technique (FAST) diagram
(Source: Macedo C. Manuel, Jr., *Value Management for Construction*, John Wiley & Sons, New York, 1978)

by" some other function are below the critical path.

These supporting functions require the construction of new critical paths. The critical path for each one of these functions must be also located on the FAST diagram.

From the above description it is obvious that the FAST diagram follows some certain rules:

a) The sequence of the critical path functions proceeding from left to right answers the question: "How is the function performed?"
b) The sequence of the critical path functions proceeding from right to left answers the question: "Why is the function performed?"
c) Functions that occur all the time and assist critical path functions appear vertically and above the critical path
d) Functions that occur at the same time and/or are caused by critical path functions are also placed vertically, but below the critical path, and
e) The basic function of the study appears at the very left side of the chart.

After the FAST diagram is constructed and the function classification is performed, the evaluation of each function can begin. First, it has to be determined who and how performs each function. The cost of performing each function can then be determined, by estimating the time, material, labor, etc. In this way the cost distribution becomes immediately apparent and the most costly critical path functions can be easily identified.

From the above description of the Function Analysis Technique it is obvious that this technique is very useful in determining the function interrelations in analyzing an entire system or a major portion of a system and it gives a better understanding of the interaction of function and cost.

Finally, it has to be noted, that for any problem under study, no "correct" FAST model exists, but only a "valid" one. The validity of the model is directly based on the experience of the team members who conduct this analysis and the scope of the related disciplines that they bring in order to bear on the problem.

4.2. The Job Plan

After determining the high-cost functions or areas of study, as indicated previously, the Value Engineering Job Plan is applied. "The Job Plan is a systematic procedure with specific steps to effectively analyze a product or a service in order to develop the maximum number of alternatives to achieve the product's or service's required functions" (SAVE, 1997).

The job plan can be applied to any area or subject suitable for study. It provides a logical plan to carry on a study from inception to conclusion. It is a five-step process and its principal phases are the informational, speculation, analysis, development and the presentation phase (Colacchia G. V., 1995). These distinct phases are presented in figure 4.2, and they are described in a detailed way in the paragraphs that follow.

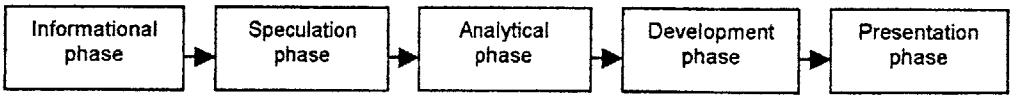


Figure 4.2. The Job Plan phases

4.2.1. The Information phase

At the first stage of the Job Plan all the relevant information should be gathered, regardless of the fact that they may seem, at least at the very beginning, unrelated to the subject. These data should include information about the subject or item under study, its performance, its estimated cost, or its actual cost -if that is possible-, and its quality. Every aspect of the item that has to do with the construction, manufacturing, fabricating, installation and operation should be questioned. Possible sources of getting these data are existing drawings and specifications, related documents and engineering manuals, test data, and material lists.

For example, the information phase for a construction project should include the original designs, the materials to be used, the construction methods that are going to be applied, the special conditions of the site, the unique problems that have to be overcome, the estimated cost, the construction schedule, etc.

After gathering all these data, the available information should be organized and the facts should be separated from the assumptions. All the data gathered should be supported by evidence.

Furthermore, it is essential to obtain information about the technologies and the processes that where used during the manufacturing, construction, or production of the item under study. Knowledge of these additional information can increase the possibility of cost reductions.

The purpose of gathering information is to obtain a precise and thorough understanding of the system or item under study and to determine the major functions being performed by this item. As soon as these major functions are described and analyzed, they are evaluated in such a way that both their duration and cost are determined.

4.2.2. The Speculation phase

The purpose of this phase is to create alternative means for accomplishing the basic functions that were identified in the first phase. As soon as the problem is understood, new ideas of how to perform the basic function are generated. These ideas introduce lower-cost alternatives and they increase the opportunity for cost savings.

The major technique used at this stage in order to prompt creative thinking is the "brainstorming technique" (Dell' Isola, 1974). According to that technique, a problem solving conference is held, in which every participant produces simultaneously ideas related to the performance of a particular function. At this point, judgement and judicial thinking should be suspended. One member's idea can motivate another member to think more creatively. The greater the number of alternatives uncovered, the greater is the possibility of developing an outstanding and satisfactory solution.

4.2.3. The Analytical phase

In this phase, which can also be considered as an evaluation and investigation phase, the alternatives that where developed in the previous phase are being evaluated and criticized. The main objective is to identify the alternatives that have the lowest risk and the greatest cost savings. During this process company specialists, suppliers, manufacturers and contractors are consulted.

All the previous developed ideas are evaluated and refined in order to meet the necessary environmental and operating conditions (Dell' Isola, 1974). This process also involves identification of faults in

these ideas. The technical aspects of each alternative are examined and the alternatives with the highest possibility of success in performance are identified.

The ideas that "survive" through this procedure are refined and analyzed further. For the alternatives that still have potential to be selected, cost estimates are conducted. These cost estimates have to be as complete and accurate as possible, in order to minimize the possibility of errors.

Finally the alternatives with the greatest cost reduction are selected to proceed to the next phase.

4.2.4. The Development phase

The objective of the Development phase is to develop final recommendations for the selected alternatives from the previous phase. Analytical technical and economic evaluations are prepared and the probability of successful implementation of these alternatives is considered.

At this point any technical problems relate to design, construction, operation and maintenance that might exist have to be determined and the technical feasibility of each alternative has to be proven. Written descriptions and sketches of both the original design and the proposed alternatives have to be prepared and cost, schedule and performance data have to be developed.

At the end one alternative is selected as the best alternative solution. For this alternative a report is prepared. This report should include a brief description of the project, the original design, the alternative design, technical data supporting the alternative, a benefit/cost analysis, a detailed cost estimate, an accurate schedule

and a list of actions necessary to implement this particular alternative (Macedo M. C., 1978).

4.2.5. The Presentation phase

The purpose of this last phase is to obtain commitment from the decision-making committee to proceed with the implementation of the recommendations. This involves both a written report and an oral presentation.

At this last phase of the value engineering study, the value engineering team has to present its recommendations to the decision-making committee. Through the presentation and the discussions that follow it, the VE team obtains either approval to proceed with the implementation of the presented solution, or direction for additional information needed (SAVE, 1997).

PART B. APPLICATION IN THE CONSTRUCTION INDUSTRY

5. VE in the Construction Industry

5.1. Characteristics of the Construction Industry

The construction industry is one of the largest industries in the United States, characterized by extreme competitiveness, low margins of profit and high risk. The cost of building products and construction services is continually rising and projects are becoming more complex and demanding. Since the construction industry has been plagued for many years by high and unnecessary costs and since investors are building for a profit, cost proves to be the predominant factor affecting both the industry and the related projects.

Furthermore, as technological innovations and advances are taking place and as owners needs and demands are changing, projects are becoming larger in scale and require more time for completion. All the activities required for the completion of a project,

from original planning and design to construction and quality control, are parts of the construction system, within which every activity adds or modifies the value of a project.

In this particular system that characterizes the construction industry, cost control has become an absolute necessity. Owners usually count either on the architect or the constructor to perform this significant function. Unfortunately, architects and designers do not have the appropriate knowledge and the required expertise to control the construction costs. In addition to that, constructors have no strong incentives to reduce these costs. On the contrary, they usually have more incentives to increase them. It is a common phenomenon for contractors to bid jobs in a low price and then make profits based on changes in the original designs. Furthermore, during the negotiations for changes in the project, contractors side with the subcontractors against the owner, since the former will probably work again with the same subcontractors in future projects.

Usually, a building project is designed by an architect under a specific contract and then construction is performed by a contractor. The contractor is selected through a competitive bidding process and starts the construction under a fixed-price contract. In other cases, a turnkey contractor, who designs and constructs the project according to the owner's needs is selected.

The delivery methods used by the public sector vary in some way from those used by the private sector. One of the basic differences is that in the public sector the bidding process is open to all contractors, while in the private sector only selected contractors can participate in the bidding process.

Due to the increasing importance of time and cost, more turnkey projects are tried and other delivery methods, such as design-build, that allow the "fast tracking" of a project are used. According to this delivery method, the owner can bid portions of the project and the

contractor can start the construction, before the final design is completed.

In other cases, a construction manager, who is responsible for the whole project, is hired. Among his responsibilities are the selection of the subcontractors and the monitoring of the construction works.

In this system that is described above, the architect's fees as well as the contractor's profits are based on a percentage of the construction costs. It is obvious, that the higher the construction costs, the more is the profit for the architect and the contractor.

5.2. Purpose of applying VE in the Construction Industry

The application of value engineering in the construction industry has two purposes; first, to provide a rigorous methodology to maximize cost reduction without degrading performance, reliability, maintenance, or safety, and second, to provide a financial incentive for contractors and subcontractors to reduce the cost of construction works, systems, and services. According to the latter, contractors who participate in value engineering share in any net savings based on their financial risk (ASC Industry Guide, 1996).

But value engineering is not profitable only to contractors. It is also useful to project owners and investors who feel that their budgets are imperiled and who want to be aware of all the existing alternative ways to construct the project.

By using a nonadversarial, problem solving approach, value engineers look at trade-offs between design concepts, construction techniques, materials, building types, and life-cycle costs and they try to arrive with the best overall value for the project. They eliminate or modify features that add cost to a construction project and at the same

time they are trying to improve its quality, life, utility, or appearance (BSA, 1998).

5.3. The Application of the Job Plan in Construction Projects

In the construction industry, the value engineering methodology can be applied whenever cost reduction or performance improvement of a specific project is required and it is applied on a project to project basis. With the application of the job plan, changes of the design can be accomplished, without extensive redesign, large implementation cost, and schedule impacts (SAVE, 1997).

During the information phase, the value engineering team gathers all the existing design data, plans, and specifications of the construction project. The construction cost, as well as the maintenance and operation costs are viewed, and the cost estimate is validated, in order to assure the budget of the project. In accordance to the owner's requirements high-cost and poor-value areas are identified.

After that, a comprehensive list of ideas is generated (speculation phase) and suggestions on possible savings are prepared. The value engineering team together with the original design team of the project review and develop further these ideas.

In the analytical phase, the ideas that where generated during the previous stage are evaluated and the high-cost areas of the construction project are analyzed. All the alternatives are investigated in detail and then one of these proposals is selected as the best solution (development phase). For this solution, final proposal report and drafts are prepared.

Finally, at the presentation phase, the report is presented to the owner of the project, who then decides for either the implementation or

the deletion of the proposal. It is interesting here to note, that the owner usually shows a keen interest on the implementation of the value engineering proposal whenever the cost estimates reveal overruns in the construction budget.

5.4. Potential Savings versus Time

Typically, all construction projects contain large elements of unnecessary costs. The application of value engineering can achieve savings and it is recommended especially when cost targets are not being met.

Value engineering can be applied at any place in the life cycle of a project, but the earlier it is applied, the more are the benefits. For maximum benefits in construction projects, the process of VE should be performed near the end of conceptual design (±80%), but prior to 30% of the final design (US Department of Energy, 1990). Furthermore, during the design and construction process, the decisions of the owner, the architect and the contractor affect the total cost of the project. This is illustrated in figure 5.1.

As indicated above, and since the architect-engineer has the most influence on the cost of a construction project, value engineering is more effective when it is applied during the design phase. As the project progresses, the number of potential net savings are reduced. But this does not mean that after a specific point in the project no benefits can result. It only indicates that the potential cost reductions are diminishing as the project proceeds. The potential savings during the life of a construction project are presented in figure 5.2.

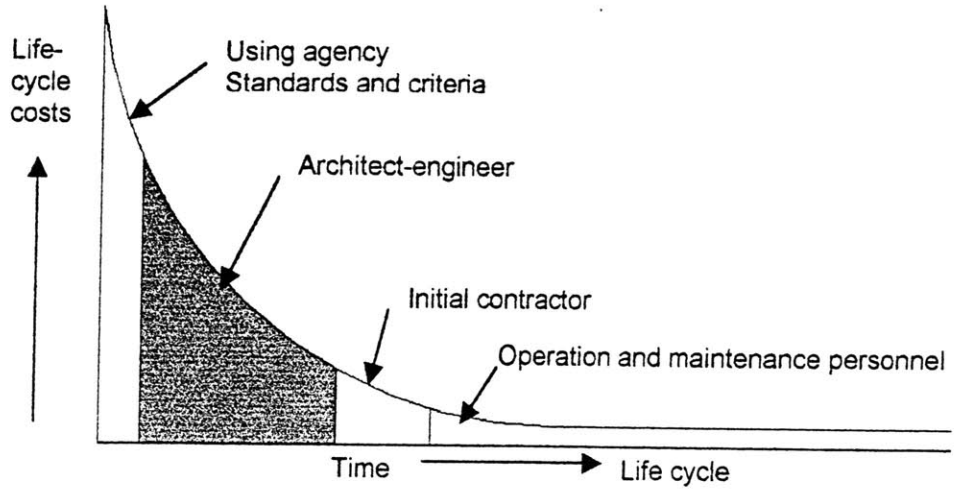


Figure 5.1. Decision-makers' influence on cost

(Source: Macedo C. Manuel, Jr., *Value Management for Construction*, John Wiley & Sons, New York, 1978)

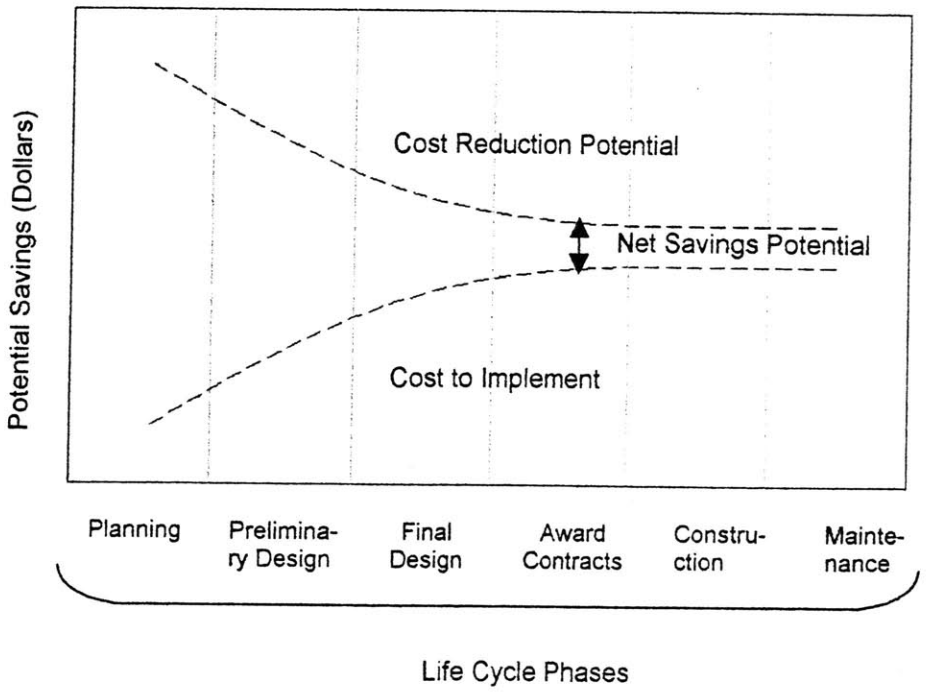


Figure 5.2. VE Savings during Life of a Construction Project

(Source: Kolla E.J., *Highway Design Standards and Value Engineering – A Synthesis*, SAVE International Conference Proceedings, File No. 97t4, pp.317-325, 1997)

5.5. VE during the Several Phases of a Construction Project

5.5.1. VE during the Conceptual Design

The conceptual design phase is defined as "the stage in a project's development, at which the planning process is complete, but the design contract has not yet been awarded or the in-house design team has not yet begun design" (Gernerd, 1993). Value engineering analysis can be conducted at this phase, as soon as the preferred alternative has been selected. At this stage, the major project functions are conceptually designed. It is useful, before the final design begins, to evaluate these functions by using the value engineering methodology.

The amount of costs avoided if value engineering is applied at this point can be very significant for the owner of the construction project. Furthermore, if the cost of the project proves to be very high the design may completely change direction. In addition to that, redesign costs can be eliminated.

5.5.2. VE during the Design Phase

During the design phase plans and specifications that conform to the owner's requirements and needs are developed, and materials, equipment, and construction methods are determined. Factors, such as function, cost, maintenance and appearance, affect significantly the design team's efforts.

The design studies and selections are made by individual engineers or groups within the same engineering discipline. For

example, the civil engineering team selects the water systems, the electrical engineering team is responsible for the generators and the conductors, and so on. Each engineer or team is trying to approach a particular part the project in the most safe and economical way. Although this system may be successful for specific functions and parts of the construction project, it tends to sacrifice the overall system performance in order to maximize the subsystem performance (Macedo M. C., 1978). Each function of the project is close related to and affects other parts and elements of the project, and so what may seem to be the most efficient and economical way for one function may be the most expensive for another one.

In this way only the initial cost of the project is considered. The failure to design for the total life cycle of the project leads to additional costs, such as increased maintenance and operation costs.

It is obvious that the architect/engineer's decisions have the greatest impact on the project, both on the initial and life cycle cost, and the performance. And since the aim of the design team is to satisfy the owner's demands, with relatively low life-cycle costs (Shen Q., 1997), intensive value engineering efforts have to be performed at this stage. The application of value engineering as a part of the design process will help the coordination of the design efforts and will assist in obtaining maximum value and minimum cost for the project.

5.5.3. VE during the Construction Phase

The application of value engineering is very important during the construction phase, since this is the last opportunity to reduce any unnecessary initial or life cycle costs. Responsible for the success or failure of the value engineering efforts in this phase, are the

construction manager, if one is assigned to the project, and the contractors.

Since the competition among contractors is high, they usually prepare their bids in such a way that their profits from the construction of the project are minimized. An opportunity to increase profits after the contract is awarded is by implementing a value engineering study. A thorough investigation on construction procedures and latest construction methods may reveal a more economical way to build the project. For example, a method that will reduce the amount of labour required at the job site might lead to significant construction savings. The contractor's value engineering efforts are awarded with a percentage of the savings realized form their value engineering proposals (Table 5.1). Furthermore, the contractor's VE efforts are encouraged by the Federal Acquisition Regulation (Appendix A).

In addition to that, the construction manager should constantly encourage contractors for VE efforts and proposals. Furthermore, the former can review the specific contract requirements and initiate changes that will eliminate the construction cost, as well as the operation and maintenance costs. In this whole process of creating alternative solutions, it is important that the construction manager tries to eliminate the necessity of changes, especially if these changes tend to increase the contract cost.

Contract type		Contractor's Share of Savings	
		First-Cost Savings	**LCC (Collateral) Savings**
Construction	Fixed Price	55 Percent	20 Percent of Savings to be realized in a typical year of use*
	Cost	25 Percent	20 Percent of Savings to be realized in a typical year of use*
Design-Build (Mandatory VE clause)	Fixed Price	25 Percent	20 Percent of Savings to be realized in a typical year of use*
	Incentive	Same sharing arrangement as contractor's profit or fee adjustment formula	20 Percent of Savings to be realized in a typical year of use*
	Cost Reimbursement**	15 Percent	20 Percent of Savings to be realized in a typical year of use*
Design-Build (Voluntary VE clause)	Fixed Price	50 Percent	20 Percent of Savings to be realized in a typical year of use*
	Incentive	Same sharing arrangement as contractor's profit or fee adjustment formula	20 Percent of Savings to be realized in a typical year of use*
	Cost Reimbursement**	25 Percent	20 Percent of Savings to be realized in a typical year of use*

* Not to exceed the lesser of the contract amount at the time of acceptance of the Value Engineering Change Proposal (VECP) or $100,000.
** Includes cost-plus-award-fee contracts.

Table 5.1.

(Source: U.S. General Services Administration-Public Buildings Service, *Value Engineering Program Guide for Design and Construction*, Internal Operations and Management, Volume I, Dec. 1992)

6. Case Study: "Regional Transportation Center, Woburn, Massachusetts"

6.1. Description of the Project

The Regional Transportation Center (RTC) site is located in Woburn, MA, north of Route 128 and west of Route 93, on the former Industri-Plex Superfound site about one mile north of the existing Mishawum Commuter Rail and Logan Express Station (Figure 6.1). This 34-acre transportation center will house Massport's Woburn Logan Express bus Service, MassHighway's Park and Ride carpool and the MBTA's relocated commuter rail service. It is designed to have 2,400 parking spaces and the purpose of its construction is to "encourage commuters to leave their cars behind and travel in trains, plains and buses" (The Commonwealth of Massachusetts Executive Department, 2000).

It is a Design-Bid-Build project constructed under the joint venture of the Massachusetts Port Authority (Massport), the Massachusetts Bay Transportation Authority (MBTA), and the Massachusetts Highway Department (MHD). The design of the project was assigned to Stone & Webster in August 1997 and was completed in October 1998. For the construction of the project, which started in January 2000 and is expected to finish one year later, Middlesex Corporation was hired as a general contractor.

6.2. The Purpose of the VE Study

The budget that was originally approved for the construction of the Regional Transportation Center was $4,335,000 and the project manager was concerned that the construction of the project would end to be above budget. As the approved budget was low, there was a possibility that it had to be increased. The project manager's aim was to increase it as little as possible. In order to succeed that and have a control on the budget, he decided to conduct three value-engineering studies during the design of the project.

These value engineering efforts were made in cooperation with the designer, first during the preliminary phase of the design, then at the 30% of the design, and finally at the 60% of the design.

The above mentioned efforts will be analyzed in detail in the following paragraphs.

6.3. VE during the Preliminary Design

During the preliminary design phase a major subject of discussion and focus of effort has been the layout of the site. The main

premise of the preliminary site access design was that the main access road onto the site should be a smooth transition from Atlantic Avenue towards the Station Building, in order to provide vehicles entering the site with a welcoming view of the Station Building. The concept was to provide a welcoming view to the Station Building, by creating landscaped areas on either side of the access road, that are framing the building. The benefits of this arrangement included a free flowing traffic movement to the Station Building area and a direct view of the Station Building.

According to this plan, access to the bus terminal area, the long term parking area, the drop-off/pick-up area, and the taxi drop-off/pick-up area, from the main site access road, had to be provided. The operational aspect of these areas was a major concern during the preliminary stage of design. In respect to that, the design team developed four alternative layouts (Appendix B):

- Alternative Layout 1: The first alternative that was developed improved the entrance road geometry to eliminate the need for land taking at the north side of the road at Atlantic Avenue.

- Alternative Layout 2: In the second alternative layout, the bus terminal area and the drop-off/pick-up area were placed adjacent to the building. In order to maintain the view of the Station Building when entering the site, both these areas were shown at a 45-degree angle.

- Alternative Layout 3: This alternative proposed that the location of the Station Building should be perpendicular to the railroad tracks, with the bus terminal area on the north side of the building and the drop-off/pick-up area on the south side of the building.

- Alternative Layout 4: The fourth layout alternative maintained the angled approach to the Station Building from Atlantic Avenue, as in Alternative 2. The drop-off/pick-up area was placed adjacent to the building, which was located adjacent to the track platform.

The value engineering efforts at this phase were focused on the evaluation of these four alternatives. The purpose of value engineering at this point was to identify which of the four alternatives was more functional. According to that, the first alternative was discarded, due to the fact that the bus and the patron traffic circulation patterns were not carefully considered. The second alternative provided complicated traffic movements at the site entrance area, and included a very limited drop-off/pick-up area adjacent to the Station Building. The third alternative provided adequate parking spaces for the long-term parking area and the daily parking area, but the traffic pattern that was proposed was very confusing for the vehicles entering the site. During this evaluation, the fourth alternative that was developed seemed to be the most functional. Convenient access to vehicles entering the site was provided and an efficient traffic circulation pattern was developed.

In addition to the alternatives that were developed for the site layout, several alternatives were also developed for the Station Building layout. Three alternatives proposed an "L" shaped building, and one proposed a rectangular building. Among these, the rectangular shaped building (Appendix B) seemed to be the most efficient one.

For both the forth layout alternative of the site and the rectangular building, a preliminary cost estimate was conducted (Appendix C). The construction cost of the site was estimated to be $3,293,105 and the construction cost of the building $1,340,758. According to this, the overall construction cost was $4,633,863.

6.4. VE at 30% of Design

The construction cost of the project, as it was estimated in the preliminary design phase, exceeded the approved budget. Furthermore it was obvious, that as the design was becoming more detailed, the cost would increase further.

At the 30% of design Stone & Webster prepared a new cost estimate for the construction of the project (Appendix D). According to this, the construction cost of the site was $3,665,236, the cost of the building was $1,451,867 and the total cost $5,117,103.

The need for a new value engineering effort was now obvious. The estimated cost was again exceeding the approved budget for the project, and before the design evolved more, cost reductions had to be made, with respect to both the quality and the functionality of the final product.

Cost reductions totaling $552,507 were accepted for sitework, reducing the estimated construction cost for site work to $3,112,729, and cost reductions totaling $184,244 were accepted for the building, reducing the estimated construction cost for the building to $1,267,623. The combined reductions for both the sitework and the building totaled $736,751, reducing the estimated total construction cost from $5,117,103 to $4,380,352 (Appendix D). This was still $45,352 above the budget of $4,335,000 for "siteside" construction.

6.5. VE at 60% of Design

Another estimate of construction cost was conducted by Stone & Webster for the 60% level of design completion. The sitework

construction cost was $3,310,887, the building construction cost $1,363,270, and the total construction cost $4,674,158 (Appendix E). In this estimate a 5% AFI (Allowance for Indeterminates) was added to the cost. Due to this addition the estimated cost exceeded the construction cost budget, that was originally identified for the project.

In order to identify possible reductions in construction cost to a level acceptable to Massport and the other user agencies, a new value engineering study was conducted. Several options that would reduce further the construction cost of both sitework and the building were identified. The total of options recommended by the design team would reduce the sitework cost by $223,582 to $3,087,305, the building cost by $121,443 to $1,241,827, and so the total construction cost by $345,025 to $4,329,133 (Appendix E).

6.6. Conclusion

The last cost estimate that was conducted was at the 100% completion of the design. According to that final estimate the total cost of the construction of the Regional Transportation Center was $4,470,883 (Appendix F). Unfortunately, this exceeded again the budget that was originally identified for the project, but was expected from the beginning of the design.

By implementing value-engineering studies at three critical phases of the design only a 3% increase of the original budget was required. This increase in the budget was not due to unsuccessful application of value engineering, but due to several extra costs that were added to the project during the design, as for example the 5% AFI.

What is remarkable is that, if value-engineering efforts had not taken place during the design of the project, this percentage of

increase would be much higher. At the 30% of the design for example, and before value engineering was applied, the estimated cost was above the initially approved budget by about 18%; and as the design would later become more detailed, this percentage would be definitely increased.

The cost estimate of the project, including value-engineering reductions, versus time is presented is presented in figure 6.2.

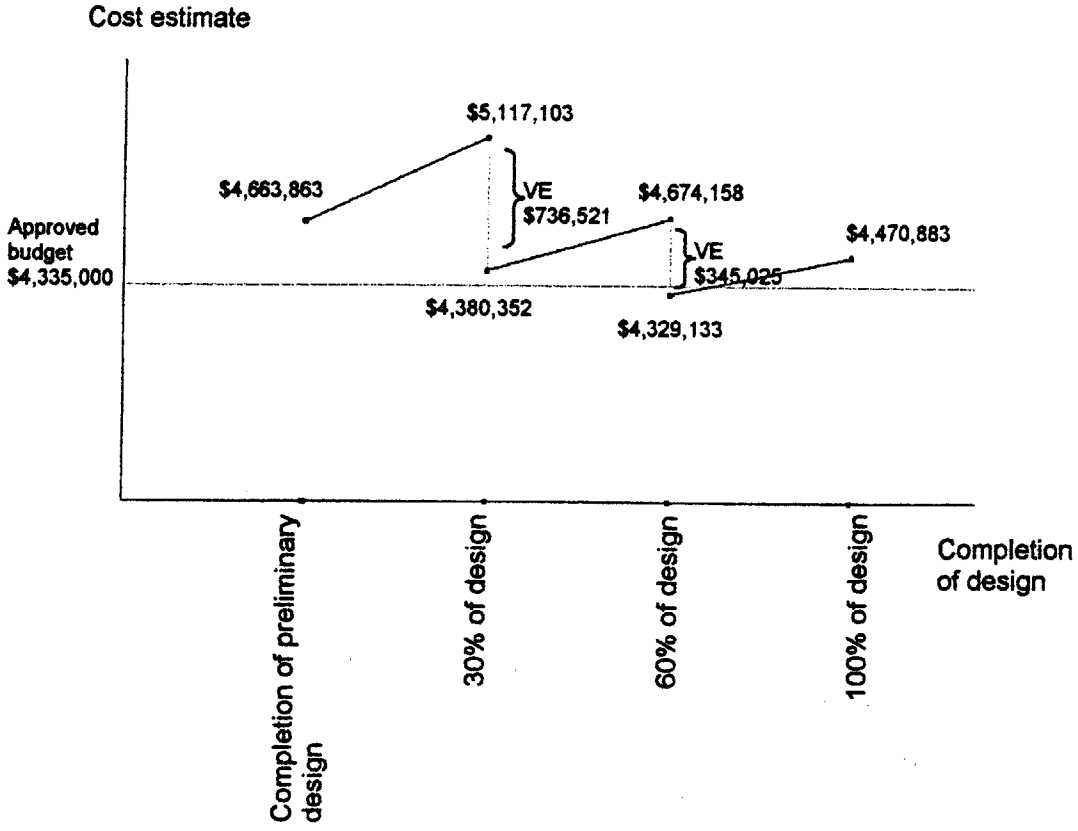


Figure 6.2. Cost estimate vs % of completion of design

7. Conclusions and Recommendations

A very critical point in applying value-engineering methodology is the selection of the time that it should be applied. As mentioned in a previous chapter, the results of a value engineering study are maximized, when it is applied late at the conceptual stage of design, or during the beginning of the final design. The proper time for selecting to implement a value engineering study in a construction project is influenced by two factors: first, the potential savings, and second, the level of difficulty of applying the VE methodology.

Furthermore, the purpose of applying VE differs as the design of a project involves. For example, in the case of the Regional Transportation Center, the purpose of the VE study at the end of the preliminary design phase was to evaluate the developed alternatives and help in the selection of the most appropriate and efficient one. This was done with respect to the expected performance of the project. The changes proposed at this point had a significant effect in the design and their purpose was not really to identify possible reductions in both

the cost and the characteristics of the project, but to identify key features that would add to its performance. This is very clearly illustrated in the case of the Station Building. The original (conceptual) design proposed a building that did not include the clock tower that is shown in the final design (Appendix B). This was added later to the building, during the first VE effort, and the purpose of this change was to improve the quality, the aesthetics, and the function of the building.

Later in the design process, and as the design was becoming more complicated and detailed, the purpose of the VE studies was to control the cost of the project and maintain a balance between the estimated cost and the approved budget.

Another key issue in implementing value engineering is the qualifications and the composition of the value engineering team. Very often value-engineering studies are conducted by design professionals, who are not certified value engineers. These sort of value-engineering studies undermine the professional status and credibility of the designer and can reduce the quality and the safety of the project. In order to obtain a good understating of the VE methodology and the proper time to apply it, all members of the VE team should acquire value engineering training, before implementing VE studies.

Team members should be very carefully selected. One of the critical success factors is the cooperation among the participants in a VE study. Information are flowing all the time among the VE team members, who are usually people from different engineering disciplines, and a good communication among them is essential for the success of value engineering.

Value Engineering specialists should be hired as top managers to coordinate VE efforts. Among their responsibilities is to foster an increased cost-consciousness between engineering personnel and their field representatives.

Compensation for value engineers should never be based on the savings carved out of the original design. Such arrangements create conflicts between the designer and the owner and they should be avoided. When value engineering is to be applied, it has to be mentioned very clearly in the contract. In order to avoid possible conflicts, both the owner and the designer should have a clear understanding about obligations to redesign based on value engineering decisions.

Further research should be made on contract clauses that include value engineering, and how they affect the relationship between the owner and the designer. What happens when the designer does not agree with the proposed value engineering changes and believes that they are not appropriate for implementation. It is very interesting to see what happens when a project has to be redesigned several times and how the designer's work is awarded in this case.

8. Bibliography – References

1. Acharya P., Pfrommer C. and Ziybel C., *Think Value Engineering*, Journal of Management in Engineering, Vol. 11, No. 6, pp. 13-17, November/December 1995
2. Al-yousefi A.S., *Total Value Management (TVM): A VE-TQM Integration*, SAVE International Conference Proceedings, File No. 9603, pp. 11-17, 1996
3. ASC, *Value Engineering*, ASCE Industry Guide, Oct. 1996
4. Boston Society of Architects, *What Every Owner Needs to Know About Value Engineering*, Building Design and Construction, Jan. 1998
5. Colacchia G. V., *Estimating for Value Engineering*, SAVE International Conference Proceedings, File No. 9508, pp. 57-61, 1995
6. Dell' Isola J. Alphonse, *Value Engineering in the Construction Industry*, Construction Publishing Company, Inc., New York, 1974
7. Federal Acquisition Regulation
8. Fong Wah Sik Patrick, *Establishing Value Engineering as an Academic Discipline Worldwide*, SAVE International Conference Proceedings, File No. 9712, pp. 82-90, 1997
9. Fong Wah Sik Patrick, *VE in Construction: A Survey of Clients' Attitudes in Hong Kong*, SAVE International Conference Proceedings, File No. 9611, pp. 63-69, 1996
10. Gernerd Kurt, *Successful Application of Value Engineering at Conceptual Stage of Design*, SAVE International Conference Proceedings, File No. 9305, 1993
11. Heller D. Edward, *Value Management: Value Engineering and Cost Reduction*, Addison-Wesley Publishing Company, Inc., New York, 1971
12. Jefferson C. C., Jr., *Winning Ways*, SAVE International Conference Proceedings, File No. 9513, pp. 94-98
13. Kirk S. J., Formisano R. A., *Responding to New Market Opportunities: Program Value Management (PVM)*, SAVE International Conference Proceedings, File No. 9503, pp. 20-25, 1995

14. Kolla E.J., *Highway Design Standards and Value Engineering – A Synthesis*, SAVE International Conference Proceedings, File No. 97t4, pp. 317-325, 1997
15. Locke M. and Randall E., *Management of Value in the British Construction Industry*, SAVE International Conference Proceedings, File No. 9404, 1994
16. Macedo C. Manuel, Jr., *Value Management for Construction*, John Wiley & Sons, New York, 1978
17. Mansour F. F., *VE Rectifies Design Basis*, SAVE International Conference Proceedings, File No. 97t5, pp. 326-328, 1997
18. Massport, *Regional Transportation Center*, Project No. 1.727, April 1999
19. Massport, *Regional Transportation Center*, Project No. 1.727, Aug. 1998
20. Massport, *Regional Transportation Center*, Project No. 1.727, Dec. 1998
21. Massport, *Regional Transportation Center*, Project No. 1.727, Jan. 1998
22. Massport, *Regional Transportation Center*, Project No. 1.727, Jun. 1998
23. Massport, *Regional Transportation Center*, Project No. 1.727, Oct. 1998
24. Miles D. Lawrence, *Techniques of Value Analysis and Engineering*, McGraw-Hill Book Company, New York, 1972
25. Nakagami Yoshio, *VE Application and Management in Japanese Construction Sector*, SAVE International Conference Preceedings, File No. 9630, pp. 183-188, 1996
26. Raven D. A., *Profit Improvement by Value Analysis, Value Engineering and Purchase Price Analysis*, Cassell & Company Ltd., London, 1971
27. SAVE, *Function Analysis Systems Technique – The Basics*, SAVE International Conference Proceedings, May 1997
28. SAVE, *Value Methodology Standard*, SAVE International Conference Proceedings, May 1997
29. Shen Q., *Value Management in Hong Kong' s Construction Industry: Lessons Learned*, SAVE International Conference Proceedings, File No. 9737, pp. 260-265, 1997
30. Smith L. Ken, *Applying Value Analyses to a Value Engineering Program*, AAHSTO VE Conference, 1999

31. Sperling R. B., *Value Analysis as a Collaborative Process*, SAVE International Conference Proceedings, File No. 9636, pp. 228-231, 1996
32. The Commonwealth of Massachusetts Executive Department, *Celluci Breaks Ground on Regional Transportation Center*, Boston, April 2000
33. Tufty Harold, *Value Engineering Made Mandatory on EPA Projects Over $10,000,000*, Civil Engineering – ASCE, Vol. 46, No. 9, pp. 101-103, Sept. 1976
34. U.S. Department of Energy-Richland Operations Office, *Value Engineering*, RL Implementing Policy/Procedure, RLIPP 4010.1, 1990
35. U.S. General Services Administration-Public Buildings Service, *Value Engineering Program Guide for Design and Construction*, Internal Operations and Management, Volume I, Dec. 1992

APPENDIX A

Federal Acquisition Regulation

52.248-2 Value Engineering - - Architect – Engineer

(a) *General.* The Contractor shall (1) perform value engineering (VE) services and submit progress reports as specified in the Schedule; and (2) submit to the Contracting Officer any resulting value engineering proposals (VEP's). Value engineering activities shall be performed concurrently with, and without delay to, the schedule set forth in the contract. The services shall include VE evaluation and review and study of design documents immediately following completion of the 35 percent design stage or at such stages as the Contractor Officer may direct. Each separately priced line item for VE services shall define specifically the scope of work to be accomplished and may include VE studies of items other than the design documents. The Contractor shall be paid as the contract specifies for this effort, but shall not share in savings which may result from acceptance and use of VEP's by the Government.

(b) *Definitions.* "Life cycle cost", as used in this clause, is the sum of all costs over the useful life of a building, system or product. It includes the cost of design, construction, acquisition, operation, maintenance, and salvage (resale) value, if any.

"Value engineering", as used in this clause, means an organized effort to analyze the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, reliability, quality, and safety.

"Value engineering proposal", as used in this clause, means, in connection with an A-E contract, a change proposal developed by employees of the Federal Government or contractor value engineering personnel under contract to an agency to provide value engineering services for the contract or program.

(c) *Submissions.* After award of an architect-engineering contract the contractor shall - -

(1) Provide the Government with a fee breakdown schedule for the VE services (such as criteria review, task team review, and bid package review) included in the contract schedule:

(2) Submit, for approval by the Contracting Officer, a list of team members and their respective resumes representing the engineering disciplines required to complete the study effort, and evidence of the team leader's qualifications and engineering discipline. Subsequent changes or substitutions to the approved VE team shall be submitted in writing to the Contracting Officer for approval; and

(3) The team leader shell be responsible for pre-study work assembly and shall edit, reproduce, and sign the final report and each VEP. All VEP's, even if submitted earlier as an individual submission, shall be contained in the final report.

(d) *VEP preparation.* As a minimum, the contractor shall include the following information in each VEP:

(1) A description of the difference between the existing and proposed design, the comparative advantages and disadvantages of each, a justification when an item's function is being altered, the effect of the change on system or facility performance, and any pertinent objective test data.

(2) A list and analysis of design criteria or specifications that must be changed if the VEP, if accepted.

(3) A separate detailed estimate of the impact on project cost of each VEP, if accepted and implemented by the Government.

(4) A description and estimate of costs the Government may incur in implementing the VEP, such as design change cost and test and evaluation cost.

(5) A prediction of any effects the proposed change may have on life cycle cost.

(6) The effect the VEP will have on design or construction schedules.

(e) *VEP acceptance.* Approved VEP's shall be implemented by bilateral modification to this contract.

(End of clause)

52.248-3 Value Engineering - - Construction

(a) *General.* The Contractor is encouraged to develop, prepare, and submit value engineering change proposals (VECP's) voluntarily. The Contractor shall share in any instant contract savings realized

from accepted VECP's, in accordance with paragraph (f) of this clause.

(b) *Definitions.* "Collateral costs", as used in this clause, means agency costs of operation, maintenance, logistic support, or Government-furnished property.

"Collateral savings", as used in this clause, means those measurable net reductions resulting from VECP in the agency's overall projected collateral costs, exclusive of acquisition savings, whether or not the acquisition cost changes.

"Contractor's development and implementation costs", as used in this clause, means those costs the Contractor incurs on a VECP specifically in developing, testing, preparing, and submitting the VECP, as well as those costs the Contractor incurs to make the contractual changes required by Government acceptance of a VECP.

"Government costs", as used in this clause, means those agency costs that result directly from developing and implementing the VECP, such as any net increases in the cost of testing, operations, maintenance, and logistical support. The term does not include the normal administrative costs of processing the VECP.

"Instant contract savings", as used in this clause, means the estimated reduction in Contractor cost of performance resulting from acceptance of the VECP, minus allowable Contractor's development and implementation costs, including subcontractors' development and implementation costs (see paragraph (h) of this clause).

"Value engineering change proposal (VECP)" means a proposal that - -

(1) Requires a change to this, the instant contract, to implement; and

(2) Results in reducing the contract price or estimated cost without impairing essential functions or characteristics; *provided*, that it does not involve a change - -

(i) In deliverable end item quantities only; or

(ii) To contract type only.

(c) *VECP preparation.* As a minimum, the Contractor shall include in each VECP the information described in paragraphs (c)(1) through (7) of this clause. If the proposed change is affected by contractually required configuration management or similar procedures, the instructions in those procedures relating to format, identification, and priority assignment shall govern VECP preparation. The VECP shall include the following:

(1) A description of the difference between the existing contract requirement and that proposed, the comparative advantages and disadvantages of each, a justification when item's function or characteristics are being altered, and the effect of the change on the end item's performance.

(2) A list and analysis of the contract requirements that must be changed if the VECP is accepted, including any suggested specification revisions.

(3) A separate, detailed cost estimate for (I) the affected portions of the existing contract requirement and (ii) the VECP . The cost reduction associated with the VECP shall take into account the Contractor's allowable development and implementation costs, including any amount attributable to subcontracts under paragraph (h) of this clause.

(4) A description and estimate of costs the Government may incur in implementing the VECP, such as test and evaluation and operating and support costs.

(5) A prediction of any effects the proposed change would have on collateral costs to the agency.

(6) A statement of the time by which a contract modification accepting the VECP must be issued in order to achieve the maximum cost reduction, noting any effect on the contract completion time or delivery schedule.

(7) Identification of any previous submissions of the VECP, including the dates submitted, the agencies and contract numbers involved, and previous Government actions, if known.

(d) *Submission.* The Contractor shall submit VECP's to the Resident Engineer at the worksite, with a copy to the Contracting Officer.

(e) Government action.

(1) The Contracting Officer will notify the Contractor of the status of the VECP within 45 calendar days after the contracting office receives it. If additional time is required, the Contracting Officer will notify the

Contractor within the 45-day period and provide the reason for the delay and the expected date of the decision. The Government will process VECP's expeditiously; however, it will not be liable for any delay in acting upon a VECP.

(2) If the VECP is not accepted, the Contracting Officer will notify the Contractor in writing, explaining the reasons for rejection. The Contractor may withdraw any VECP, in whole or in part, at any time before it is accepted by the Government. The Contracting Officer may require that the Contractor provide written notification before undertaking significant expenditures for VECP effort.

(3) Any VECP may be accepted, in whole or in part, by the Contracting Officer's award of a modification to this contract citing this clause. The Contracting Officer may accept the VECP, even though an agreement on price reduction has not been reached, by issuing the Contractor a notice to proceed with the change. Until a notice to proceed is issued or a contract modification applies a VECP to this contract, the Contractor shall perform in accordance with the existing contract. The decision to accept or reject all or part of any VECP is a unilateral decision made solely at the discretion of the Contracting Officer.

(f) *Sharing* - - (1) *Rates*. The Government's share of savings is determined by subtracting Government costs from instant contract savings and multiplying the result by - -

(i) 45 percent for fixed-price contracts; or

(ii) 75 percent for cost-reimbursement contracts.

(3) *Payment.* Payment of any share due to the Contractor for use of a VECP on this contract shall be authorized by a modification to this contract to - -

(i) Accept the VECP;

(ii) Reduce the contract price or estimated cost by the amount of instant contract savings; and

(iii) Provide the Contractor's share of savings by adding the amount calculated to the contract price or fee.

(g) *Collateral savings.* If a VECP is accepted, the Contracting Officer will increase the instant contract amount by 20 percent of any projected collateral savings determined to be realized in a typical year of use after subtracting any Government costs not previously offset. However, the Contractor's share of collateral savings will not exceed the contract's firm-fixed-price or estimated cost, at the time the VECP is accepted, or $100,ooo, whichever is greater. The Contracting Officer id the sole determiner of the amount of collateral savings.

(h) *Subcontracts.* The Contractor shall include an appropriate value engineering clause in any subcontract of $50,000 or more and may include one in subcontracts of lesser value. In computing any adjustment in this contract's price under paragraph (f) of this clause, the Contractor's allowable development and implementation costs shall include any subcontractor's allowable development and implementation costs clearly resulting from a VECP accepted by the Government under this contract, but shall exclude any value engineering incentive payments to a subcontractor. The Contractor

may choose any arrangement for subcontractor value engineering incentive payments; *provided*, that these payments shall not reduce the Government's share of the savings resulting from the VECP.

(i) *Data*. The Contractor may restrict the Government's right to use any part of a VECP or the supporting data by marking the following legend on the affected parts:

These data, furnished under the Value Engineering - - Construction clause of contract _____, shall not be disclosed outside the Government or duplicated, used, or disclosed, in whole or in part, for any purpose other than to evaluate a value engineering change proposal submitted under the clause. This restriction does not limit the Government's right to use information contained in these data if it has been obtained or is otherwise available from the Contractor or from another source without limitations.

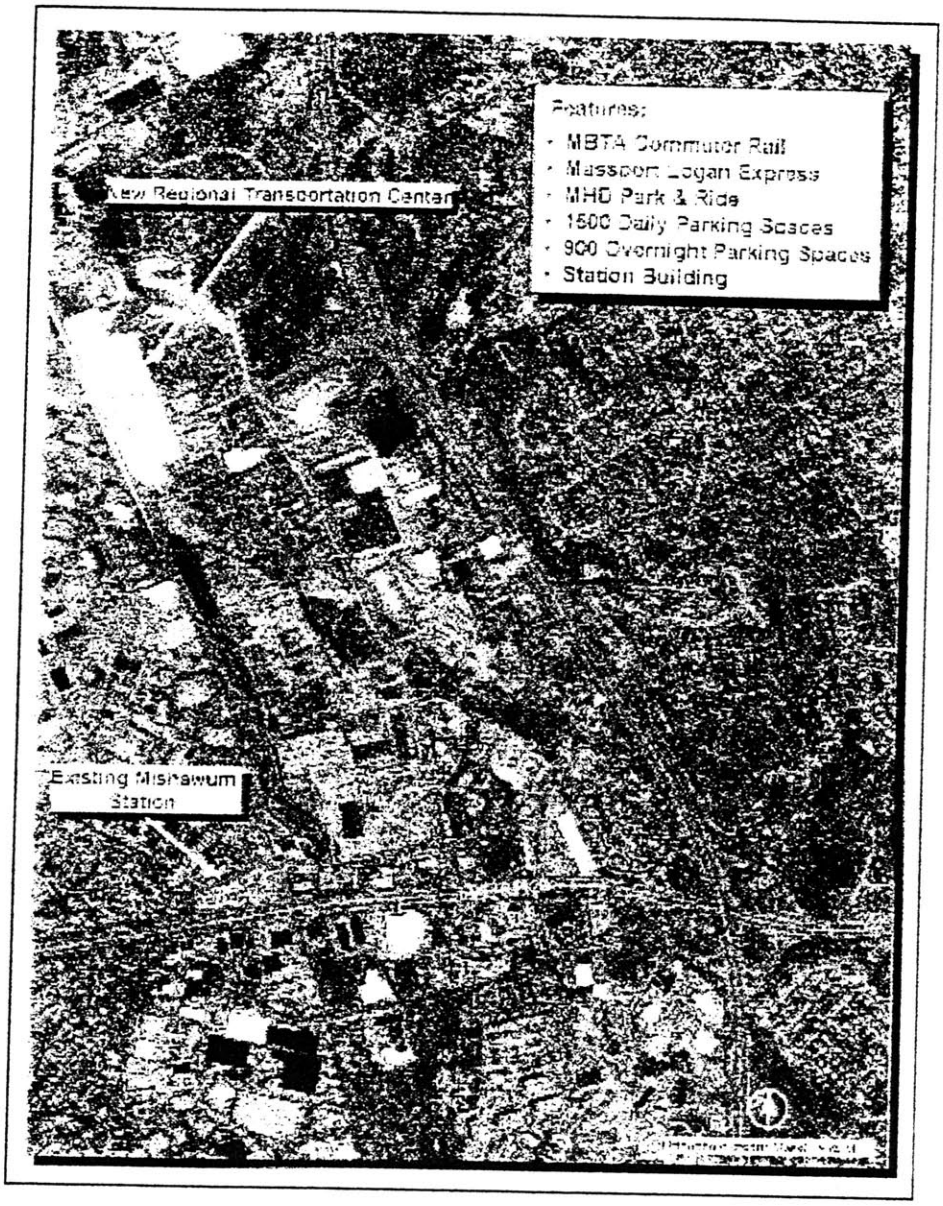
If a VECP is accepted, the Contractor hereby grants the Government unlimited rights in the VECP and supporting data, except that, with respect to data qualifying and submitted as limited rights technical data, the Government shall have the rights specified in the contract modification implementing the VECP and shall appropriately mark the data. (The terms "unlimited rights" and "limited rights" are defined in Part 27 of Federal Acquisition Regulation).

(End of clause)

(Alternate I (Apr 1984). When the head of the contracting activity determines that the cost of calculating and tracking collateral savings will exceed the benefits to be derived in a construction

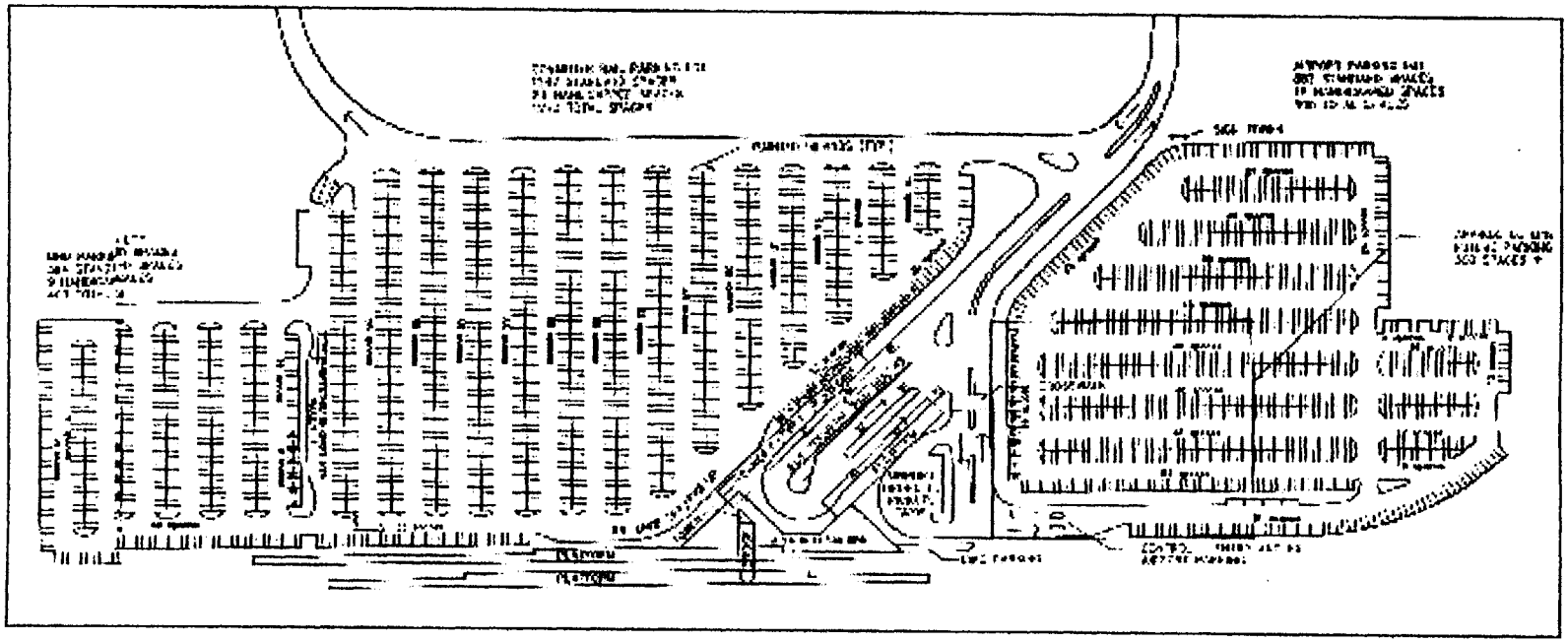
contract, delete paragraph (g) from the basic clause and redesignate the remaining paragraphs accordingly.

Appendix B



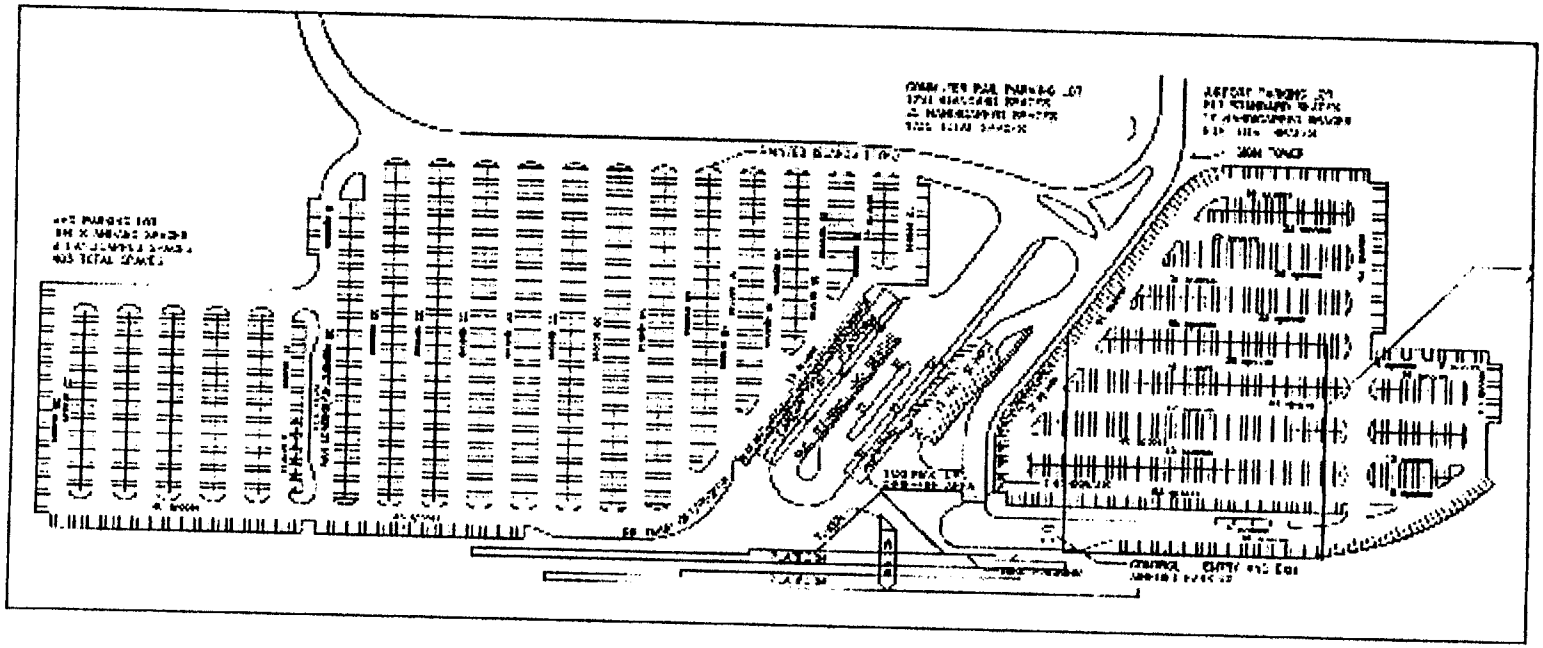
Location of the project

(Source: Massport)



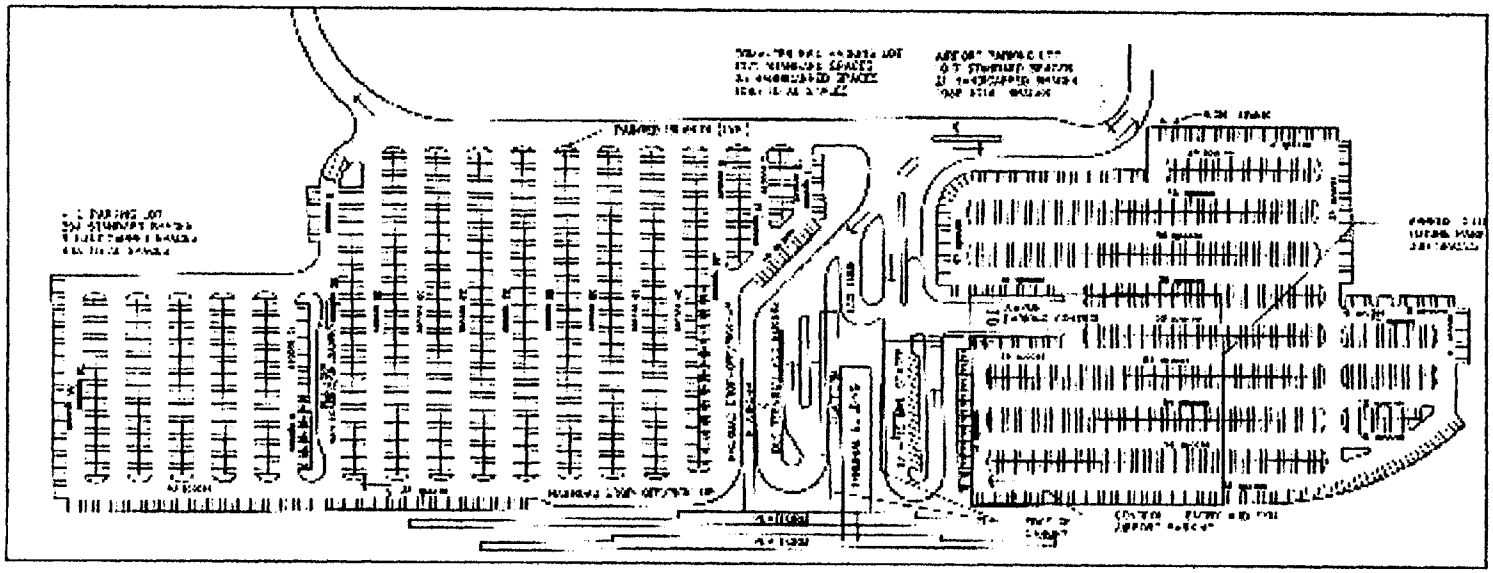
First alternative of the layout

(Source: Massport, *Regional Transportation Center*, Project No. 1.727, April 1999)



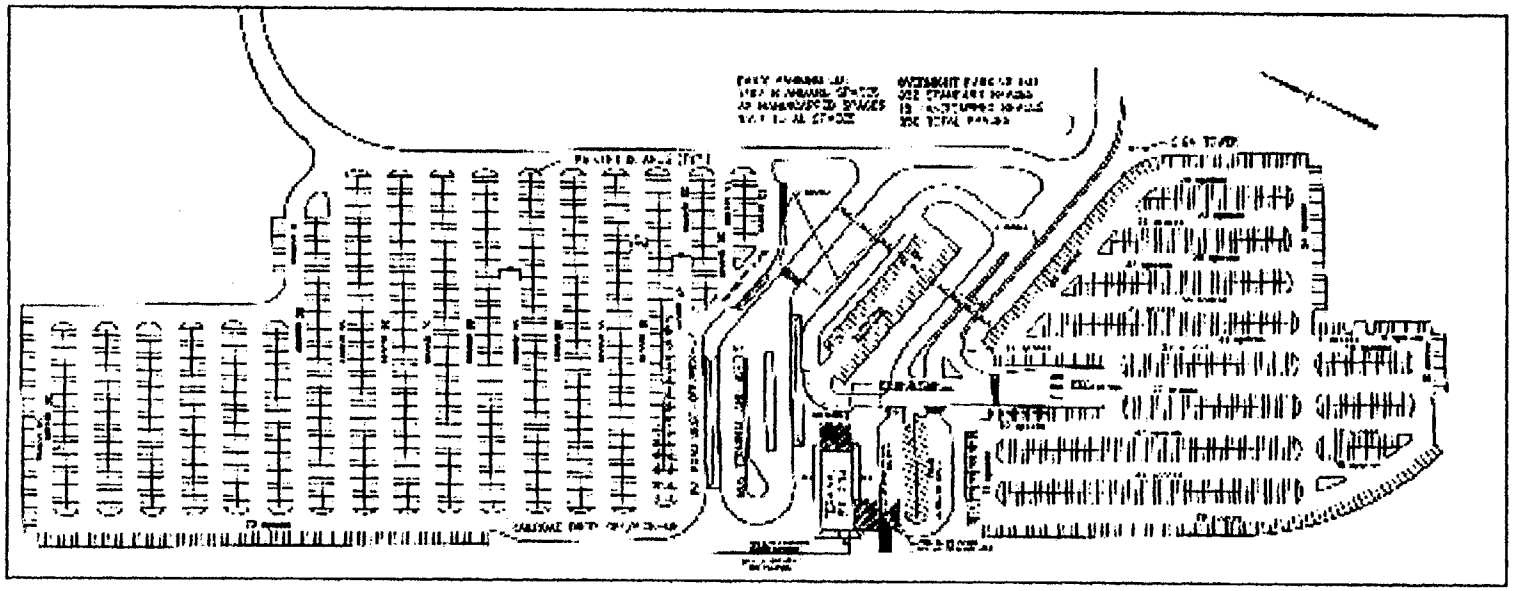
Second alternative of the layout

(Source: Massport, *Regional Transportation Center*, Project No. 1.727, April 1999)



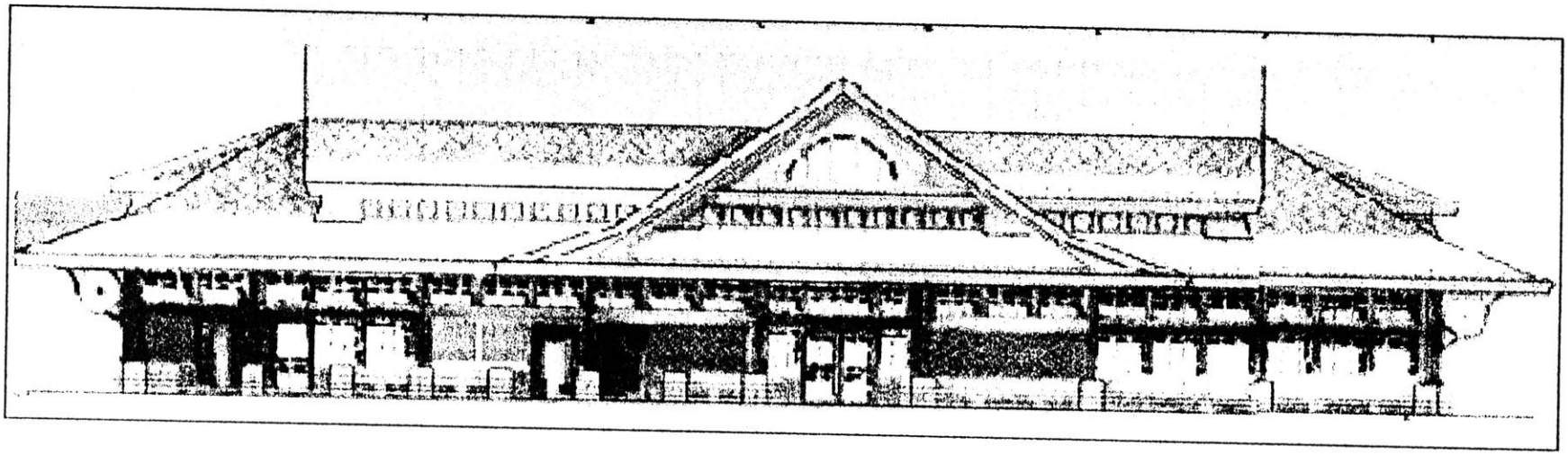
Third alternative of the layout

(Source: Massport, *Regional Transportation Center*, Project No. 1.727, April 1999)



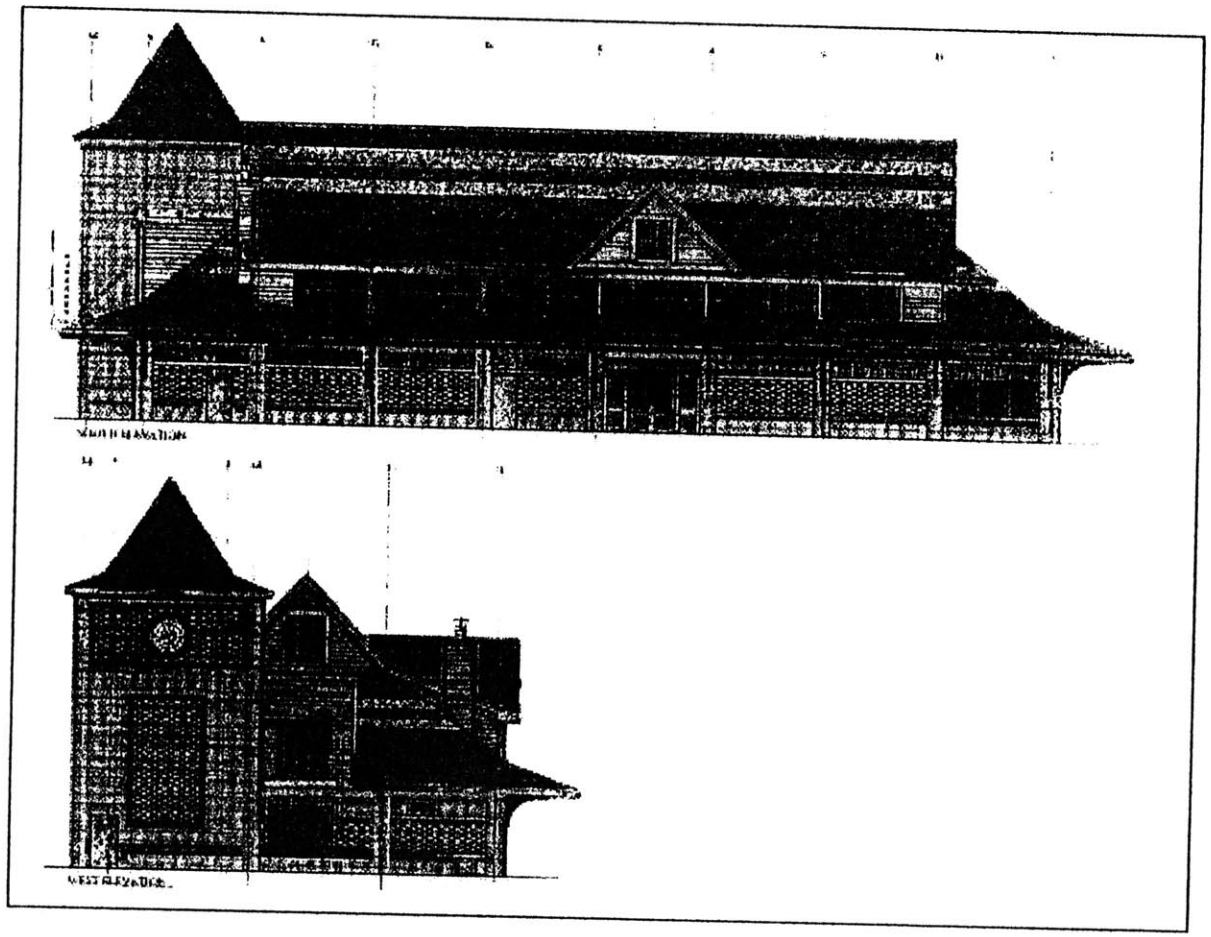
Fourth alternative of the layout

(Source: Massport, *Regional Transportation Center*, Project No. 1.727, April 1999)



Original Design of the Station Building

(Source: Massport, *Regional Transportation Center*, Project No. 1.727, April 1999)



Final Design of the Station Building

(Source: Massport)

Appendix C

PRELIMINARY DESIGN REPORT
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2	SITE SIDE CONSTRUCTION								
2.1	SITEWORK								
2.1.1	EARTHWORK								
2.1.1.1	field offices (2) - for MPA Res. Eng and siteside contractor	12	mon	$2,400.00		$2,400.00	$28,800		$28,800
2.1.1.2	sheetpiling around deep excavation for tie-in to existing 20" water main (assume 10'x10'x20' sheeting; install and remove when no longer required)	800	sf	$24.00		$24.00	$19,200		$19,200
2.1.1.3	dewatering of deep excavation for tie-in to existing 20" main (approved method for disposal of contaminated groundwater is required)	1	ls	$10,000.00		$10,000.00	$10,000		$10,000
2.1.1.4	excavation and backfill of contaminated soils in deep excavation for tie-in to existing 20" water main (assume 10'x10'x15' deep excavation)	55	cy	$20.00		$20.00	$1,100		$1,100
2.1.1.5	fine grading	96,000	cy	$1.12		$1.12	$107,520		$107,520
2.1.1.6	gravel borrow for filling to subgrade	46,900	cy	$8.61		$8.61	$403,809		$403,809
2.1.1.7	excavation and backfill for utilities	6,000	cy	$5.50		$5.50	$33,000		$33,000
2.1.1.99	SUBTOTAL: EARTHWORK						$574,629		$574,629
2.1.2	SIDEWALKS, CURBING, PAVING, AND STRIPING								
2.1.2.1	4" thick concrete sidewalks	44,768	sf	$3.00		$3.00	$134,304		$134,304
2.1.2.2	4" thick concrete sidewalks, with decorative finish	15,000	sf	$4.00		$4.00	$60,000		$60,000
2.1.2.3	6" dia painted steel pipe bollards embedded in concrete base, for protection of fire hydrants in parking areas	24	ea	$500.00		$500.00	$12,000		$12,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.2.4	6" thick portland cement concrete pavement at busway	500	cy	$90.00		$90.00	$45,000		$45,000
2.1.2.5	Class I bituminus concrete pavament - base course mix	2,800	tn	$32.00		$32.00	$89,600		$89,600
2.1.2.6	Class I bituminus concrete pavament - top course mix	21,000	tn	$32.00		$32.00	$672,000		$672,000
2.1.2.7	3' wide brick paving feature strip around Station Building	1,020	sf	$20.00		$20.00	$20,400		$20,400
2.1.2.8	vertical granite curbing - straight	6,700	lf	$18.53		$18.53	$124,151		$124,151
2.1.2.9	vertical granite curbing - curved	1,600	lf	$23.90		$23.90	$428,240		$428,240
2.1.2.10	sloped granite curbing	6,800	lf	$11.00		$11.00	$74,800		$74,800
2.1.2.11	4" wide pavement striping - yellow	62,000	lf	$0.25		$0.25	$15,500		$15,500
2.1.2.12	12" wide pavement striping - white	825	lf	$1.00		$1.00	$825		$825
2.1.2.13	handicapped striping and symbols	32	ea	$40.00		$40.00	$1,280		$1,280
2.1.2.99	SUBTOTAL: SIDEWALK, CURB, PAVING, STRIPING						$1,288,100		$1,288,100
2.1.3	UTILITIES								
2.1.3.1	4" cament-lined ductile iron water pipe for connecton to building	20	lf	$26.00		$26.00	$520		$520
2.1.3.2	4" gate valve and box	1	ea	$450.00		$450.00	$450		$450
2.1.3.3	6" cement-lined ductile iron water pipe for fire service	1,800	lf	$42.00		$42.00	$75,600		$75,600
2.1.3.4	6" gate valve and box	7	ea	$600.00		$600.00	$4,200		$4,200
2.1.3.5	fire hydrant	7	ea	$1,600.00		$1,600.00	$11,200		$11,200
2.1.3.6	installation of 20" cament-lined ductile iron water pipe for fire service	1,500	lf		$26.10	$26.10		$39,150	$39,150
2.1.3.7	connect to existing 20" City water main (20" gate valves and boxes to be furnished by City, installed by this contract)	2	ea		$2,499.75	$2,499.75		$5,000	$5,000
2.1.3.8	6" PVC pipe for sanitary sewer service from building	220	lf	$22.00		$22.00	$4,840		$4,840
2.1.3.9	connect to existing sanitary sewer system	1	ea	$1,000.00		$1,000.00	$1,000		$1,000
2.1.3.10	allowance to cover installation of new gas line from Atlantic Avenue to Station Building (by Boston Gas Co. or sitework contractor)	800	lf	$15.00		$15.00	$12,000		$12,000
2.1.3.11	allowance to cover connection of new gas line into existing gas main in Atlantic Avenue (by Boston Gas. Co. or sitework contractor)	1	ea	$2,000.00	$900.00	$2,900.00	$2,000	$900	$2,900
2.1.3.99	SUBTOTAL: UTILITIES						$111,810	$45,050	$156,860
2.1.4	STORM DRAINAGE								
2.1.4.1	12" dia Class V reinforced concrete pipe for storm drain	260	lf	$24.00	$9.00	$33.00	$6,240	$2,340	$8,580
2.1.4.2	drop inlet catch basin	7	ea	$1,000.00		$1,000.00	$7,000		$7,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.4.3	construct new catch basin over existing drainage culvert	10	ea	$900.00		$900.00	$9,000		$9,000
2.1.4.4	CB or MH frame and cover	40	ea	$285.00		$285.00	$11,400		$11,400
2.1.4.99	SUBTOTAL: STORM DRAINAGE						$33,640	$2,340	$35,980
2.1.5	FENCING, GUARDRAIL, SIGNAGE								
2.1.5.1	6' high vinyl coated chain link fence (around 3 sides of long-term parking, and around dumpster/transformer/condenser unit areas)	1,500	lf	$18.00		$18.00	$27,000		$27,000
2.1.5.2	12' wide gate in 6' high chain link fence	5	ea	$770.00		$770.00	$3,850		$3,850
2.1.5.3	6' high steel ornamental fence (along access road of long term parking)	600	lf	$90.00		$90.00	$54,000		$54,000
2.1.5.4	steel guardrail and posts, highway type (along parking and roadways where adjacent grade drops)	3,500	lf	$13.00		$13.00	$45,500		$45,500
2.1.5.5	signs with sign posts, for directional signage	1	ls	$15,000.00		$15,000	$15,000		$15,000
2.1.5.99	SUBTOTAL: FENCING, GUARDRAIL, SIGNAGE						$145,350		$145,350
2.1.6	PLANTING								
2.1.6.1	6" loam and seed (around 3 sides of site)	17,000	sy	$3.10		$3.10	$52,700		$52,700
2.1.6.2	geotextile fabric over crushed stone	1,520	sf	$0.35		$0.35	$532		$532
2.1.6.3	excavation for trees	127	cy	$4.50		$4.50	$572		$572
2.1.6.4	concrete edge strip (along curbline of planted areas abutting heavily travelled roadways)	1,500	lf	$6.00		$6.00	$9,000		$9,000
2.1.6.5	loam (2' deep in planting areas, 12" deep in grass areas	1,729	cy	$25.00		$25.00	$43,225		$43,225
2.1.6.6	trees in allees (3" to 3.5" caliper, staked and guyed)	76	ea	$1,000.00		$1,000.00	$76,000		$76,000
2.1.6.7	trees at entry sign/tower (20' height, multi-stemmed red maple)	5	ea	$1,000.00		$1,000.00	$5,000		$5,000
2.1.6.8	seed	36,500	sf	$0.25		$0.25	$9,125		$9,125
2.1.6.9	plant maintenance	1	ls	$6,685.00		$6,685.00	$6,685		$6,685
2.1.6.99	SUBTOTAL: PLANTING						$202,839		$202,839
2.1.7	SITE ACCESSORIES								
2.1.7.1	irrigation system	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.1.7.2	bicycle rack-9 bike size (assume 0.75% of patrons arrive by bicycle=0..75x2400=18 spaces)	2	ea	$1,500.00		$1,500.00	$3,000		$3,000
2.1.7.3	8' long free-standing ornamental metal metal bench	10	ea	$1,500.00		$1,500.00	$15,000		$15,000
2.1.7.4	site trash receptacles	10	ea	$250.00		$250.00	$2,500		$2,500
2.1.7.99	SUBTOTAL: SITE ACCESSORIES						$40,500		$40,500

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.8	SITE ELECTRICAL								
2.1.8.1	utility ductbank-concrete with spacers, etc.	135	cy	$90.00		$90.00	$12,150		$12,150
2.1.8.2	2" PVC conduit-schedule 80, direct buried (for site and roadway lighting)	5,000	lf	$3.20		$3.20	$16,000		$16,000
2.1.8.3	4" PVC conduit-schedule 40, to be encased, (see concrete above)	7,200	lf	$4.00		$4.00	$28,800		$28,800
2.1.8.4	1" galvanized rigid steel conduit	1,500	lf	$4.94		$4.94	$7,410		$7,410
2.1.8.5	1-1/2" galvanized rigid steel conduit	100	lf	$2.35		$2.35	$235		$235
2.1.8.6	ground rod with clamp	4	ea	$127.06		$127.06	$508		$508
2.1.8.7	load center-installed	4	ls	$10,000.00		$10,000.00	$40,000		$40,000
2.1.8.8	no. 8 THW wire	18,000	lf	$0.65		$0.65	$11,700		$11,700
2.1.8.9	pull rope	12,000	lf	$0.14		$0.14	$1,680		$1,680
2.1.8.10	18' light pole-installed (for pedestrian lighting around building)	35	ls	$750.00		$750.00	$26,250		$26,250
2.1.8.11	foundation for 18' light pole	35	ea	$200.00		$200.00	$7,000		$7,000
2.1.8.12	250w light-installed (for pedestrian lighting, mounted on 18'pole)	35	ls	$500.00		$500.00	$17,500		$17,500
2.1.8.13	40' light pole-installed (for roadway lighting along driveways/ roads)	13	ls	$1,500.00		$1,500.00	$19,500		$19,500
2.1.8.14	foundation for 40' light pole	13	ea	$300.00		$300.00	$3,900		$3,900
2.1.8.15	150w light-installed (for pedestrian lighting, mounted on 40'pole)	13	ls	$360.00		$360.00	$4,680		$4,680
2.1.8.16	80' light pole-installed (for parking lot lighting, long and short term)	11	ls	$3,600.00		$3,600.00	$39,600		$39,600
2.1.8.17	foundation for 80' light pole	11	ea	$1,000.00		$1,000.00	$11,000		$11,000
2.1.8.18	1000w light-installed (for parking lot lighting, mounted on 80'pole)	66	ls	$4,490.00		$4,490.00	$32,340		$32,340
2.1.8.19	CCTV system	1	ls	$25,000.00		$25,000.00	$25,000		$25,000
2.1.8.20	CCTV wire	4,500	lf	$0.75		$0.75	$3,375		$3,375
2.1.8.99	SUBTOTAL: SITE ELECTRICAL						$308,628		$308,628
2.1.9	PARKING AND REVENUE CONTROL								
2.1.9.1	master meter pay stations-for users of daily parking lot (4 located along track sidewalk, 2 near van platform, and 2 in Station Building)	8	ea	$8,000.00	$1,080.00	$9,080.00	$64,000	$8,640	$72,640
2.1.9.2	pay-on-foot central cashier station-for users of long-term parking lot (read ticket, calculate fee, accept payment, validate ticket, send data to computer)	1	ea	$60,000.00	$4,800.00	$64,800.00	$60,000	$4,800	$64,800
2.1.9.3	parking gate-for long-term parking lot (2 inbound lanes, 2 outbound lanes)	4	ea	$3,500.00	$450.00	$3,950.00	$14,000	$1,800	$15,800

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.9.4	ticket dispenser (machine readable) - for long-term parking lot (2 inbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.5	validated ticket reader (machine readable) - for long-term parking lot (2 outbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.6	fee computer (ticket counter cashier terminal, tied-in to pay-on-foot unit)	1	ea	$10,000.00	$1,080.00	$11,080.00	$10,000	$1,080	$11,080
2.1.9.7	detector loops (2 each, at each, at each inbound and outbound gates)	8	ea	$500.00	$180.00	$680.00	$4,000	$1,440	$5,440
2.1.9.8	computer (network for master meters/pay-on-foot/cashier)	1	ea	$4,000.00	$540.00	$4,540.00	$4,000	$540	$4,540
2.1.9.9	computer software-including training	1	ea	$6,000.00	$720.00	$6,720.00	$6,000	$4,720	$6,720
2.1.9.99	SUBTOTAL: PARKING AND REVENUE CONTROL						$210,000	$24,780	$234,780
2.1.10	MISCELLANEOUS SITE STRUCTURES								
2.1.10.1	Site canopies at bus platforms-(2) 12'x168' half-canopies at Logan Express and local bus berths (assume galvanized steel, similar to MBTA standard half-canopies, including foundations, lighting)	4,032	sf	$35.00		$35.00	$141,120		$141,120
2.1.10.2	Site canopies at park-and-ride platforms-(2)12'x48'half-canopies at van loading areas (assume galvanized steel, similar to MBTA half-canopies, including foundations and lighting)	1,152	sf	$35.00		$35.00	$40,320		$40,320
2.1.10.3	Sign tower structure at Atlantic Avenue entrance-assume steel framed, with logo signs for 3 agencies, including foundations and lighting	1	ea	$40,000.00		$40,000.00	$40,000		$40,000
2.1.10.4	Site Maintenance Storage Building-10'x12' pre-fabricated steel with metal panels, mounted on slab-on-grade, electric and lights)	1	ea	$12,000.00		$12,000.00	$12,000		$12,000
2.1.10.5	Clock pedestal in front of Station Building-assume four clock faces on one free-standing pedestal, including foundations and lifhting	1	ea	$10,000.00		$10,000.00	$10,000		$10,000
2.1.10.6	Flag poles in front of Station Building-assume (2) manually operated flag poles, 20'-25' high, including foundations and flags	2	ea	$3,000.00		$3,000.00	$6,000		$6,000
2.1.10.99	SUBTOTAL: MISCELLANEOUS SITE STRUCTURES						$249,440		$249,440
2.1.11	SITESIDE ENVIRONMENTAL SERVICES								
2.1.11.1	Licenced Site Professional on-site during critical earthwork operations	1	ls		$48,000.00	$48,000.00		$48,000	$48,000
2.1.11.2	laboratory testing services	1	ls		$8,000.00	$8,000.00		$8,000	$8,000
2.1.11.3	SUBTOTAL: SITESIDE ENVIRONMENTAL SERVICES							$56,000	$56,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.99						SUBTOTAL: SITEWORK	$3,164,936	$128,170	$3,293,105

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Jan. 1998)

PRELIMINARY DESIGN REPORT
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2	**STATION BUILDING - SCHEME 1 (RECTANGULAR, 111'X61')**								
2.2.1	EARTHWORK								
2.2.1.1	building excavation (121x61x2.5) from exist grade, including backfill or disposal	683	cy	$4.50		$4.50	$3,074		$3,074
2.2.1.2	impervious liner under building, wrap up exterior of fdn wall (121x61)	7,381	sf	$1.50		$1.50	$11,072		$11,072
2.2.1.3	furnish/place/compact struct fill on top of liner to underside slab (109x49x4)	792	cy	$8.00		$8.00	$6,336		$6,336
2.2.1.4	4" perforated PVC pipe under slab for vapor collection, including vents	522	lf	$6.00		$6.00	$3,132		$3,132
2.2.1.99	SUBTOTAL: EARTHWORK						$23,613		$23,613
2.2.2	CONCRETE								
2.2.2.1	exterior foundation and dado walls (1x3x322) and footings (3x1x208)	59	cy	$100.00	$180.00	$280.00	$5,900	$10,620	$16,520
2.2.2.2	exterior column footings and piers-22 total @ (5x5x1.5+1x1x3)	33	cy	$120.00	$225.00	$345.00	$3,960	$7,425	$11,385
2.2.2.3	interior column footings and piers-14 total @ (3x3x1.3+1.3x1.3x1.3)	8	cy	$120.00	$225.00	$345.00	$960	$1,800	$2,760
2.2.2.4	elevator pit walls, miscellaneous pads, etc	5	cy	$150.00	$270.00	$420.00	$750	$1,350	$2,100
2.2.2.5	6" slab on grade for ground floor, including mesh reinforcing (109x49)	99	cy	$120.00	$135.00	$255.00	$11,880	$13,365	$25,245
2.2.2.6	4.5" elevated slab on metal deck for mezzanine, including reinforcing but not metal deck (14x203)	36	cy	$150.00	$270.00	$420.00	$5,400	$9,720	$15,120
2.2.2.7	exterior transformer pads, condenser foundations, dumpster pad	7	cy	$150.00	$270.00	$420.00	$1,050	$1,890	$2,940
2.2.2.99	SUBTOTAL: CONCRETE						$29,900	$46,170	$76,070
2.2.3	MASONRY								
2.2.3.1	8" load bearing CMU-back-up on exterior wall (9)(322-48)	2,466	sf	$3.00	$5.40	$8.40	$7,398	$13,316	$20,714
2.2.3.2	4" face brick-exterior wall (9)(322-48)	2,466	sf	$5.00	$6.75	$11.75	$12,330	$16,646	$428,976
2.2.3.99	SUBTOTAL: MASONRY						$19,728	$29,962	$49,690
2.2.4	STRUCTURAL STEEL								
2.2.4.1	structural steel framing for roof, mezzanine and columns	19	tn	$1,400.00	$675.00	$2,075.00	$26,250	$12,656	$38,906
2.2.4.2	metal decking for mezzanine (1-1/2" composite, 20 ga)	2,842	sf	$2.00	$1.80	$3.80	$5,684	$5,116	$10,800

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.4.3	metal framing for roof (cold-rolled, 18 ga channel)	17,800	sf	$2.50	$1.80	$4.30	$44,500	$32,040	$76,540
2.2.4.4	painted steel handrail-perimeter of mezzanine (188), interior stairs (90)	278	lf	$30.00	$4.50	$34.50	$8,340	$1,251	$9,591
2.2.4.5	ornamental ironwork-exterior brackets under eaves	24	ea	$2,000.00		$2,000.00	$48,000		$48,000
2.2.4.99	SUBTOTAL: STRUCTURAL STEEL						$132,774	$51,063	$183,837
2.2.5	WOODS AND PLASTICS								
2.2.5.1	rough carpentry	1	ls	$5,000.00	$5,400.00	$10,400.00	$5,000	$5,400	$10,400
2.2.5.2	3/4" T&G plywood sheathing-roof deck	17,800	sf	$1.00	$0.68	$1.68	$17,800	$12,015	$29,815
2.2.5.3	bead board-interior ceiling and exterior eaves	15,876	sf	$2.00	$1.35	$3.35	$31,752	$21,433	$53,185
2.2.5.4	finish carpentry-trim	1	ls	$53,070.00		$53,070.00	$53,070		$53,070
2.2.5.5	base cabinets-ticketing area	30	lf	$200		$200.00	$6,000		$6,000
2.2.5.6	counter tops-ticketing and food areas	55	lf	$60.00		$60.00	$3,300		$3,300
2.2.5.99	SUBTOTAL: WOODS AND PLASTICS						$116,922	$38,848	$155,770
2.2.6	THERMAL AND MOISTURE PROTECTION								
2.2.6.1	dampproofing and waterproofing	1	ls	$4,500.00		$4,500.00	$4,500		$4,500
2.2.6.2	wall insulation-6" fiberglass	3,832	sf	$0.35	$0.36	$0.71	$1,341	$1,380	$2,721
2.2.6.3	roof insulation-12" fiberglass	17,800	sf	$0.50	$0.36	$0.86	$8,900	$6,408	$15,308
2.2.6.4	rigid insulation-1-1/2" (interior face foundation walls-2.5x314)	785	sf	$0.40	$0.68	$1.08	$314	$530	$844
2.2.6.5	standing seam metal roof	17,800	sf	$3.50	$1.80	$5.30	$62,300	$32,040	$94,340
2.2.6.6	metal gutter	700	lf	$2.00	$4.50	$6.50	$1,400	$3,150	$4,550
2.2.6.7	metal downspout and leader	250	lf	$2.00	$2.25	$4.25	$500	$563	$1,063
2.2.6.8	roof flashing and trim	1,000	sf	$5.00	$6.75	$11.75	$5,000	$6,750	$11,750
2.2.6.9	caulking and sealants	1	ls	$6,000.00		$6,000.00	$6,000		$6,000
2.2.6.99	SUBTOTAL: THERMAL AND MOISTURE PROTECTION						$90,255	$50,820	$141,075
2.2.7	DOORS AND WINDOWS								
2.2.7.1	3'-0" hollow metal door, including hardware	16	ea	$750.00	$180.00	$930.00	$12,000	$2,880	$14,880
2.2.7.2	6'-0" automatic sliding glass doors (including 8'x12' painted metal storefront frame, glass, hardware, electric openers, etc.)	5	ea	$9,200.00	$1,800.00	$11,000.00	$46,000	$9,000	$55,000
2.2.7.3	6' high bulletproof glass (exterior wall of ticketing area)	150	sf	$50.00	$9.00	$59.00	$7,500	$1,350	$8,850
2.2.7.4	10' roll-up grilles	3	ea	$2,500.00	$360.00	$2,860.00	$7,500	$1,080	$8,580
2.2.7.5	6' glass wall (interior wall of ticketing area)	84	sf	$25.00	$9.00	$34.00	$2,100	$756	$2,856
2.2.7.6	3'x3' custom wood window/awning	112	ea	$300.00	$90.00	$390.00	$33,600	$10,080	$43,680
2.2.7.99	SUBTOTAL: DOORS AND WINDOWS						$108,700	$25,146	$133,846

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.8	FINISHES								
2.2.8.1	4" metal studs-25 gauge	3,000	sf	$0.45	$0.90	$1.35	$1,350	$2,700	$4,050
2.2.8.2	6" metal studs-18 gauge	3,000	sf	$0.90	$0.90	$1.80	$2,700	$2,700	$5,400
2.2.8.3	1/2" gypboard	11,964	sf	$0.20	$0.90	$1.10	$2.39	$10,768	$13,160
2.2.8.4	1/2" gypboard sheathing	3,832	sf	$0.20	$0.90	$1.10	$766	$3,449	$4,215
2.2.8.5	porcelean ceramic tile-floor	3,660	sf	$6.50	$3.15	$9.65	$23,790	$11,529	$35,319
2.2.8.6	porcelean ceramic tile-toiletroom walls	1,884	sf	$4.50	$3.15	$7.65	$8,478.00	$5,935	$14,413
2.2.8.7	acoustical ceiling	2,530	sf	$1.50	$0.90	$2.40	$3,795	$2,277	$6,072
2.2.8.8	carpeting-commercial grade, no pad (bus waiting and ticketing areas on ground floor, offices on mezzanine level)	175	sy	$35.00		$35.00	$6,125		$6,125
2.2.8.9	painting-latex on drywall (primer+2 coats)	11,964	sf	$0.12	$0.45	$0.57	$1,436	$5,384	$6,819
2.2.8.10	painting-wood trim	5,000	lf	$0.12	$0.90	$1.02	$600	$4,500	$5,100
2.2.8.11	painting-acrylic urethane	15,876	sf	$0.30	$0.45	$0.75	$4,763	$7,144	$11,907
2.2.8.12	wallcovering	1	ls	$1,200.00		$1,200.00	$1,200		$1,200
2.2.8.99	SUBTOTAL: FINISHES						$57,396	$56,385	$113,781
2.2.9	SPECIALTES								
2.2.9.1	toilet partitions-painted metal, ceiling hung, including hardware	1	ls	$4,810.00		$4,810.00	$4,810.00		$4,810
2.2.9.2	toiletroom accessories (mirrors, soap dispensers, towel dispensers)	1	ls	$2,450.00		$2,450.00	$2,450.00		$2,450
2.2.9.3	miscellaneous specialties	1	ls	$13,060.00		$13,060.00	$13,060.00		$13,060
2.2.9.99	SUBTOTAL: SPECIALTIES						$20,320		$20,320
2.2.10	FURNISHINGS								
2.2.10.1	Type 1 wooden benches-exterior, under eaves	168	lf	$125.00	$15.75	$140.75	$21,000	$2,646	$23,646
2.2.10.2	Type 2 wooden benches-interior, bus waiting area	3	ea	$800.00	$90.00	$890.00	$2,400	$270	$2,670
2.2.10.3	Type 3 wooden benches-interior, main lobby	3	ea	$5,000.00	$360.00	$5,360.00	$15,000	$1,080	$16,080
2.2.10.99	SUBTOTAL: FURNISHINGS						$38,400	$3,996	$42,396
2.2.11	CONVEYING SYSTEMS								
2.2.11.1	elevator-pitless hydraulic, 2-story, completely installed	1	ls	$48,940.00		$48,940.00	$48,940		$48,940
2.2.11.99	SUBTOTAL: CONVEYING SYSTEMS						$48,940		$48,940

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.12	MECHANICAL/HVAC								
2.2.12.1	hydronic heating system-1000 MBH gas boiler	9,600	sf	$4.00	$4.50	$8.50	$38,400	$43,200	$81,600
2.2.12.2	split system air cooled-25 ton	9,600	sf	$4.50	$4.50	$9.00	$43,200	$43,200	$86,400
2.2.12.3	toiletroom ventilation	4	ea	$1,000.00	$1,080.00	$2,080.00	$4,000	$4,320	$8,320
2.2.12.4	electric hot water heater (80 gal.)-including all connections, valves, etc	1	ea	$1,000.00	$720.00	$1,720.00	$1,000	$720	$1,720
2.2.12.99	SUBTOTAL: MECHANICAL/HVAC						$86,600	$91,440	$178,040
2.2.13	PLUMBING/FIRE PROTECTION								
2.2.13.1	storm drain piping	300	lf	$5.00	$14.85	$19.85	$1,500	$4,455	$5,955
2.2.13.2	water supply piping	600	lf	$4.00	$5.63	$9.63	$2,400	$3,375	$5,775
2.2.13.3.	waste and drain piping-4"PVC	450	lf	$5.00	$14.85	$19.85	$2,250	$6,683	$8,933
2.2.13.4	vending machine piping	1	ls	$600.00	$720.00	$1,320.00	$600	$720	$1,320
2.2.13.5	wall hung toilets	6	ea	$700.00	$450.00	$1,150.00	$4,200	$2,700	$6,900
2.2.13.6	wall hung urinals	2	ea	$600.00	$450.00	$41,050.00	$1,200	$900	$2,100
2.2.13.7	wall hung water cooler	1	ea	$700.00	$360.00	$1,060.00	$700	$360	$1,060
2.2.13.8	wall hung lavoratories	5	ea	$550.00	$450.00	$1,000.00	$2,750	$2,250	$5,000
2.2.13.9	wall hung janitor sink	1	ea	$600.00	$360.00	$4,960.00	$600	$360	$960
2.2.13.10	rough-in for food area	1	ea	$500.00	$450.00	$950.00	$4,500	$450	$950
2.2.13.11	sprinkler system, wet type, ordinary hazard (interior of Station Building only)	8,200	sf	$1.26	$1.17	$2.43	$10,332	$9,594	$19,926
2.2.13.99	SUBTOTAL: PLUMBING/FIRE PROTECTION						$27,032	$31,847	$58,879
2.2.14	ELECTRICAL								
2.2.14.1	power wiring and receptacles for building-(1.2 watt/sf)	8,200	sf	$0.50	$1.44	$1.94	$4,100	$11,808	$15,908
2.2.14.2	200 amp switchgear and panel for site	1	ea	$2,500.00	$2,400.00	$4,900.00	$2,500	$2,400	$4,900
2.2.14.3	200 amp switchgear and panel for building	1	ea	$2,500.00	$2,400.00	$4,900.00	$2,500	$2,400	$4,900
2.2.14.4	200 amp switchgear and panel for commuter rail platform, track switch heaters	1	ea	$2,500.00	$2,400.00	$4,900.00	$2,500	$2,400	$4,900
2.2.14.5	electric service	1	ls	$2,000.00	$1.92	$3,920	$2,000	$1,920	$3,920
2.2.14.6	2x4 recessed flourescent fixtures (3 watts/sf)-interior low ceiling	2,800	sf	$1.72	$3.17	$4.89	$4,816	$8,870	$13,686
2.2.14.7	recessed halogen lights-interior, high bays	25	ea	$400.00	$96.00	$496.00	$10,000	$2,400	$12,400
2.2.14.8	recessed halogen lights-exterior, under eaves	28	ea	$400.00	$96.00	$496.00	$11,200	$2,688	$13,888
2.2.14.9	communications system for building (telephone, public address, etc.)	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.2.14.10	fire alarm system for building (smoke detectors, annunciation panel, etc.)	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.2.14.99	SUBTOTAL: ELECTRICAL						$79,616	$34,886	$114,502

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.99	SUBTOTAL: STATION BUILDING-SCHEME 1 (RECTANGULAR)						$880,196	$460,662	$1,340,758
2.99	TOTAL: SITE SIDE CONSTRUCTION						$4,045,132	$588,732	$4,633,863

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Jan 1998)

Appendix D

FINAL DESIGN - 30% SUBMITTAL
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2	SITE SIDE CONSTRUCTION								
2.1	SITEWORK								
2.1.1	EARTHWORK								
2.1.1.1	field office (1)-shared by MPA&MBTA Res.Eng's	12	mon	$2,400.00		$2,400.00	$28,800		$28,800
2.1.1.2	sheetpiling around deep excavation for tie-in to existing 20" water main (assume 10'x10'x20' sheeting; install and remove when no longer required)	800	sf	$24.00		$24.00	$19,200		$19,200
2.1.1.3	dewatering of deep excavation for tie-in to existing 20" main (approved method for disposal of contaminated groundwater is required)	1	ls	$10,000.00		$10,000.00	$10,000		$10,000
2.1.1.4	excavation and backfill of contaminated soils in deep excavation for tie-in to existing 20" water main (assume 10'x10'x15' deep excavation)	55	cy	$20.00		$20.00	$1,100		$1,100
2.1.1.5	fine grading	99,500	cy	$1.12		$1.12	$107,520		$107,520
2.1.1.6	gravel borrow for filling to subgrade (including 25% for compaction as per MHD guidelines	57,220	cy	$8.61		$8.61	$403,809		$403,809
2.1.1.7	excavation and backfill for utilities	6,000	cy	$5.50		$5.50	$33,000		$33,000
2.1.1.8	rip-rap for slope protection	950	cy	$30.00		$30.00	$28,500		$28,500
2.1.1.9	roadway excavation (Atlantic Ave)	225	cy	$27.00		$27.00	$6,075		$6,075
2.1.1.10	bituminous sawcutting (Atlantic Ave)	1,00	lf	$2.00		$2.00	$2,000		$2,000
2.1.1.11	pavement milling (Atlantic Ave)	1,500	sy	$5.00		$5.00	$7,500		$7,500
2.1.1.99	SUBTOTAL: EARTHWORK						$725,879		$725,879
2.1.2	SIDEWALKS, CURBING, PAVING, AND STRIPING								
2.1.2.1	4" thick concrete sidewalks	49,165	sf	$3.00		$3.00	$147,495		$147,495

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.2.2	4" thick concrete sidewalks, with decorative finish	3,000	sf	$4.00		$4.00	$12,000		$12,000
2.1.2.3	6" dia painted steel pipe bollards embedded in concrete base, for protection of fire hydrants in parking areas	29	ea	$500.00		$500.00	$14,500		$14,500
2.1.2.4	6" thick portland cement concrete pavement at busway	500	cy	$90.00		$90.00	$45,000		$45,000
2.1.2.5	Class I bituminus concrete pavament - base course mix	1,950	tn	$32.00		$32.00	$62,400		$62,400
2.1.2.6	Class I bituminus concrete pavament - top course mix	20,500	tn	$32.00		$32.00	$656,000		$656,000
2.1.2.8	vertical granite curbing - straight	5,500	lf	$18.53		$18.53	$101,915		$101,915
2.1.2.9	vertical granite curbing - curved	1,300	lf	$23.90		$23.90	$31,070		$31,070
2.1.2.10	sloped granite curbing	6,400	lf	$11.00		$11.00	$70,400		$70,400
2.1.2.11	4" wide pavement striping - yellow	63,700	lf	$0.25		$0.25	$15,925		$15,925
2.1.2.12	12" wide pavement striping - white	825	lf	$1.00		$1.00	$825		$825
2.1.2.13	handicapped striping and symbols	32	ea	$40.00		$40.00	$1,280		$1,280
2.1.2.99	SUBTOTAL: SIDEWALK, CURB, PAVING, STRIPING						$1,158,810		$1,158,810
2.1.3	UTILITIES								
2.1.3.1	4" cament-lined ductile iron water pipe for connecton to building	20	lf	$26.00		$26.00	$520		$520
2.1.3.2	4" gate valve and box	1	ea	$450.00		$450.00	$450		$450
2.1.3.3	6" cement-lined ductile iron water pipe for fire service	1,700	lf	$42.00		$42.00	$71,400		$71,400
2.1.3.4	6" gate valve and box	8	ea	$600.00		$600.00	$4,800		$4,800
2.1.3.5	fire hydrant	7	ea	$1,600.00		$1,600.00	$11,200		$11,200
2.1.3.6	installation of 20" cament-lined ductile iron water pipe for fire service	1,550	lf		$26.10	$26.10		$40,455	$40,455
2.1.3.7	connect to existing 20" City water main (20" gate valves and boxes to be furnished by City, installed by this contract)	2	ea		$2,499.75	$2,499.75		$5,000	$5,000
2.1.3.8	6" PVC pipe for sanitary sewer service from building	400	lf	$22.00		$22.00	$8,800		$8,800
2.1.3.9	connect to existing sanitary sewer system	1	ea	$1,000.00		$1,000.00	$1,000		$1,000
2.1.3.10	allowance to cover installation of new gas line from Atlantic Avenue to Station Building (by Boston Gas Co. or sitework contractor)	1,300	lf	$15.00		$15.00	$19,500		$19,500
2.1.3.11	allowance to cover connection of new gas line into existing gas main in Atlantic Avenue (by Boston Gas. Co. or sitework contractor)	1	ea	$2,000.00	$900.00	$2,900.00	$2,000	$900	$2,900
2.1.3.12	sanitary sewer manholes	3	ea	$2,000.00		$2,000.00	$6,000		$6,000
2.1.3.99	SUBTOTAL: UTILITIES						$125,670	$46,355	$172,025
2.1.4	STORM DRAINAGE								
2.1.4.1	12" dia Class V reinforced concrete pipe for storm drain	275	lf	$26.00		$26.00	$7,150		$7,150
2.1.4.2	drop inlet catch basin	8	ea	$1,000.00		$1,000.00	$8,000		$8,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.4.3	construct new catch basin over existing drainage culvert	8	ea	$900.00		$900.00	$7,200		$7,200
2.1.4.4	CB or MH frame and cover	36	ea	$285.00		$285.00	$10,260		$10,260
2.1.4.5	remove and reset CB or MH-frame and cover	8	ea	$130.00		$130.00	$1,040		$1,040
2.1.4.99	SUBTOTAL: STORM DRAINAGE						$33,650		$33,650
2.1.5	FENCING, GUARDRAIL, SIGNAGE								
2.1.5.1	6' high vinyl coated chain link fence (around 3 sides of long-term parking, and around dumpster/transformer/condenser unit areas)	1,450	lf	$18.00		$18.00	$26,100		$26,100
2.1.5.2	12' wide gate in 6' high chain link fence	3	ea	$770.00		$770.00	$2,310		$2,310
2.1.5.3	6' high steel ornamental fence (along access road of long term parking)	850	lf	$90.00		$90.00	$76,500		$76,500
2.1.5.4	steel guardrail and posts, highway type (along parking and roadways where adjacent grade drops)	3,400	lf	$13.00		$13.00	$44,200		$44,200
2.1.5.5	signs with sign posts, for directional signage	1	ls	$15,000.00		$15,000.00	$15,000		$15,000
2.1.5.6	safety signs (Atlantic Ave)	1	ea	$2,000.00		$2,000.00	$2,000		$2,000
2.1.5.99	SUBTOTAL: FENCING, GUARDRAIL, SIGNAGE						$166,110		$166,110
2.1.6	PLANTING								
2.1.6.1	6" loam and seed (around 3 sides of site)	3,133	sy	$3.10		$3.10	$9,712		$9,712
2.1.6.2	geotextile fabric over crushed stone	1,520	sf	$0.35		$0.35	$532		$532
2.1.6.3	excavation for trees	127	cy	$4.50		$4.50	$572		$572
2.1.6.4	concrete edge strip (along curbline of planted areas abutting heavily travelled roadways)	1,500	lf	$6.00		$6.00	$9,000		$9,000
2.1.6.5	loam (2' deep in planting areas, 12" deep in grass areas	2,092	cy	$25.00		$25.00	$52,300		$52,300
2.1.6.6	trees in allees (3" to 3.5" caliper, staked and guyed)	95	ea	$800.00		$800.00	$76,000		$76,000
2.1.6.7	trees at entry sign/tower (20' height, multi-stemmed red maple)	5	ea	$1,000.00		$1,000.00	$5,000		$5,000
2.1.6.8	seed	51,330	sf	$0.15		$0.15	$7,700		$7,700
2.1.6.9	plant maintenance	1	ls	$4,535.62		$4,535.62	$4,536		$4,536
2.1.6.99	SUBTOTAL: PLANTING						$165,351		$165,351
2.1.7	SITE ACCESSORIES								
2.1.7.1	irrigation system	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.1.7.2	bicycle rack, loop style	9	ea	$185.00		$185.00	$1,665		$1,665
2.1.7.3	8' long free-standing ornamental metal bench w/hardwood seat and back (on plaza)	4	ea	$808.00	$404.00	$1,212.00	$3,232	$1,616	$4,848
2.1.7.4	8' long free-standing ornamental metal bench w/hardwood seat, no back (under eaves of bldg)	16	ea	$490.00	$245.00	$735.00	$7,840	$3,920	$11,760

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.7.5	site trash receptacles	5	ea	$848.00	$52.00	$900.00	$4,240	$260	$4,500
2.1.7.99	SUBTOTAL: SITE ACCESSORIES						$36,977	$5,796	$42,773
2.1.8	SITE ELECTRICAL								
2.1.8.1	normal power-500kVA pad mounted transformer (by BECO?) normal power-primary transformer cables (3-1/c#4awg, shld rated 15kv)	1	ea	$26,000.00	$4,320.00	$30,320.00	$26,000	$4,320	$30,320
2.1.8.2	underground from Atlantic Ave pole 612/9 to transformer (20'coil+1208' u.g.+12'coil=1240'/cablex3cables=3720')	3,720	lf	$2.20	$0.45	$2.65	$8,184	$1,674	$9,858
2.1.8.3	normal power-secondary transformer cables (2-1/c#350mcp/ph w/neut & grd#2awg, rated 600v) underground from transformer to station building electric room (13'coil+85u.g.+12'coil=110'/cablex10cables=1100')	1,100	lf	$11.00	$3.15	$14.15	$12,100	$3,465	$15,565
2.1.8.4	normal power-terminations	1	ls	$6,450.00		$6,450.00	$6,450		$6,450
2.1.8.5	emergency power-125kw diesel generator set (480/277v,3ph,3w,60hz, 3ph sensing)	1	ls	$63,000.00		$63,000.00	$63,000		$63,000
2.1.8.6	emergency power-diesel generator output cables (3-1/c#300mcm,600v, xlp w/grd#3awg)-(13'coil+85'u.g.+12'coil=110'/cablex3cables=330')	330	lf	$12.50	$3.60	$16.10	$4,125	$1,188	$5,313
2.1.8.7	emergency power-automatic transfer bypass/isolation switch	1	ea	$12,000.00	$1,800.00	$13,800.00	$12,000	$1,800	$13,800
2.1.8.8	emergency power-terminations, 600v compression type lugs	1	ls	$1,025.00		$1,025.00	$1,025		$1,025
2.1.8.9	underground conduit-2"PVC, schedule 80, direct buried (for site lighting, security/communications)	13,750	lf	$1.50	$2.25	$3.75	$20,625	$30,938	$51,563
2.1.8.10	underground conduit-4"PVC, schedule 40, to be conc encased, conc not included (4 conduit duct bank, 1215' long, Atlantic Ave to Sta bldg-power tel/comm, plus 2 spares)	4,860	lf	$2.50	$42.25	$4.75	$12,150	$10,935	$23,085
2.1.8.11	underground conduit-4"rigid steel, direct buried (2 conduit, secondary+ spare, 90' each-transformer to electric room)	180	lf	$16.00	$6.75	$22.75	$2,880	$1,215	$4,095
2.1.8.12	concrete encasement for underground ductbank, including spacers, etc. (19"x19" for 4-4" conduits)	93	cy	$70.00	$20.25	$90.25	$6,510	$1,883	$8,393
2.1.8.13	1" galvanized rigid steel conduit	1,500	lf	$2.50	$2.25	$4.75	$3,750	$3,375	$7,125
2.1.8.14	1-1/2" galvanized rigid steel conduit	100	lf	$3.30	$2.70	$6.00	$330	$270	$600
2.1.8.15	ground rod with clamp	4	ea	$127.06		$127.06	$508		$508
2.1.8.16	load center-installed	4	ls	$10,000.00		$10,000.00	$40,000		$40,000
2.1.8.17	no. 8 THW wire	57,650	lf	$0.65		$0.65	$37,473		$37,473
2.1.8.18	pull rope	12,000	lf	$0.14		$0.14	$1,680		$1,680
2.1.8.19	Type S4 pedestrian lighting-14'rigid steel light pole-installed	20	ls	$1,500.00	$115.00	$1,615.00	$30,000	$2,300	$32,300
2.1.8.20	Type S4 pedestrian lighting-foundation for 14' pole	20	ea	$400.00		$400.00	$8,000		$8,000
2.1.8.21	Type S4 pedestrian lighting-100 fixture w/bracket arm (mounted 1 each on 14' pole)-installed	20	ls	$600.00	$170	$770.00	$12,000	$3,400	$15,400
2.1.8.22	Type S3twin roadway lighting-30' tapered steel pole w/twin davit-installed	3	ls	$900.00	$560.00	$1,460.00	$2,700	$1,680	$4,380

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.8.23	Type S3 twin roadway lighting-foundation for 30' pole	3	ea	$600.00		$600.00	$1,800		$1,800
2.1.8.24	Type S3 twin roadway lighting-250w fixtures (mounted 2 each on 30'pole) -installed	6	ls	$500.00	$160.00	$660.00	$3,000	$960	$3,960
2.1.8.25	Type S2 single roadway lighting-30'tapered steel pole w/single davit -installed	48	ls	$700.00	$465.00	$1,165.00	$33,600	$22,320	$55,920
2.1.8.26	Type S2 single roadway lighting-foundation for 30'pole	48	ea	$600.00		$600.00	$28,800		$28,800
2.1.8.27	Type S2 single roadway lighting-250w fixture (mounted 1 each on 30' pole)-installed	48	ls	$500.00	$160.00	$660.00	$24,000	$7,680	$31,680
2.1.8.28	Type S1 parking lot lighting-100'highmast pole, not incl. Fixture lowering device-installed	9	ls	$8,000.00	$1,240.00	$9,240.00	$72,000	$11,160	$83,160
2.1.8.29	Type S1 parking lot lighting-foundation for 100'pole	9	ea	$1,500.00		$1,500.00	$13,500		$13,500
2.1.8.30	Type S1 parking lot lighting-400w fixture (mounted 8 each on 100'pole) -installed	72	ls	$500.00	$110.00	$610.00	$36,000	$7,920	$43,920
2.1.8.31	communications system for site (telephone, piblic address, etc.)	1	ls	$17,685		$17,685	$17,685		$17,685
2.1.8.99	SUBTOTAL: SITE ELECTRICAL						$541,875	$118,483	$660,357
2.1.9	PARKING AND REVENUE CONTROL								
2.1.9.1	master meter pay stations-for users of daily parking lot (4 located along track sidewalk, 2 near van platform, and 2 in Station Building)	8	ea	$8,000.00	$1,080.00	$9,080.00	$64,000	$8,640	$72,640
2.1.9.2	pay-on-foot central cashier station-for users of long-term parking lot (read ticket, calculate fee, accept payment, validate ticket, send data to computer)	1	ea	$60,000.00	$4,800.00	$64,800.00	$60,000	$4,800	$64,800
2.1.9.3	parking gate-for long-term parking lot (2 inbound lanes, 2 outbound lanes)	4	ea	$3,500.00	$450.00	$3,950.00	$14,000	$1,800	$15,800
2.1.9.4	ticket dispenser (machine readable) - for long-term parking lot (2 inbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.5	validated ticket reader (machine readable) - for long-term parking lot (2 outbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.6	fee computer (ticket counter cashier terminal, tied-in to pay-on-foot unit)	1	ea	$10,000.00	$1,080.00	$11,080.00	$10,000	$1,080	$11,080
2.1.9.7	detector loops (2 each, at each, at each inbound and outbound gates)	8	ea	$500.00	$180.00	$680.00	$4,000	$1,440	$5,440
2.1.9.8	computer (network for master meters/pay-on-foot/cashier)	1	ea	$4,000.00	$540.00	$4,540.00	$4,000	$540	$4,540
2.1.9.9	computer software-including training	1	ea	$6,000.00	$720.00	$6,720.00	$6,000	$4,720	$6,720
2.1.9.99	SUBTOTAL: PARKING AND REVENUE CONTROL						$210,000	$24,780	$234,780

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.10	MISCELLANEOUS SITE STRUCTURES								
2.1.10.1	Site canopies at bus platforms-(2) 12'x168' half-canopies at Logan Express and local bus berths (assume galvanized steel, similar to MBTA standard half-canopies, including foundations, lighting)	4,032	sf	$35.00		$35.00	$141,120		$141,120
2.1.10.2	Site canopies at park-and-ride platforms-(2)12'x48'half-canopies at van loading areas (assume galvanized steel, similar to MBTA half-canopies, including foundations and lighting)	1,152	sf	$35.00		$35.00	$40,320		$40,320
2.1.10.3	Sign tower structure at Atlantic Avenue entrance-assume steel framed, with logo signs for 3 agencies, including foundations and lighting	1	ea	$40,000.00		$40,000.00	$40,000		$40,000
2.1.10.4	Site Maintenance Storage Building-10'x12' pre-fabricated steel with metal panels, mounted on slab-on-grade, electric and lights)	1	ea	$12,000.00		$12,000.00	$12,000		$12,000
2.1.10.5	exterior transformer pads, condenser foundations, dumpster pad	45	cy	$100.00	$180.00	$280.00	$4,500	$8,100	$12,600
2.1.10.6	8" load bearing CMU-transformer, dumster, etc area	312	sf	$3.00	$5.40	$8.40	$936	$1,685	$2,621
2.1.10.7	6' high chain link fence gates	42	lf	$20.00		$20.00	$840		$840
2.1.10.99	SUBTOTAL: MISCELLANEOUS SITE STRUCTURES						$239,716	$9,785	$249,501
2.1.11	SITESIDE ENVIRONMENTAL SERVICES								
2.1.11.1	Licenced Site Professional on-site during critical earthwork operations	1	ls		$48,000.00	$48,000.00		$48,000	$48,000
2.1.11.2	laboratory testing services	1	ls		$8,000.00	$8,000.00		$8,000	$8,000
2.1.11.3	SUBTOTAL: SITESIDE ENVIRONMENTAL SERVICES							$56,000	$56,000
2.1.99						SUBTOTAL: SITEWORK	$3,404,038	$261,198	$3,665,236

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Jun. 1998)

FINAL DESIGN - 30% SUBMITTAL
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2	STATION BUILDING - SCHEME 1 (RECTANGULAR, 116'-6""X49'-4"")								
2.2.1	EARTHWORK								
2.2.1.1	building excavation (5x2.5x326.5) from exist grade, including backfill or disposal	151	cy	$4.50		$4.50	$680		$680
2.2.1.2	impervious liner under building, wrap up exterior of fdn wall (121x52)	6,292	sf	$2.00		$2.00	$12,584		$12,584
2.2.1.3	furnish/place/compact struct fill on top of liner to underside slab (114.50x47.33x1.00)	201	cy	$20.00		$20.00	$4,020		$4,020
2.2.1.4	4" perforated PVC pipe under slab for vapor collection, including vents (8x49.33+1x116.50)	512	lf	$10.00		$10.00	$5,120		$5,120
2.2.1.99	SUBTOTAL: EARTHWORK						$22,404		$22,404
2.2.2	CONCRETE								
2.2.2.1	exterior foundation and dado walls (1x3x327.67) and footings (3x1x217.67)	61	cy	$100.00	$180.00	$280.00	$6,100	$10,980	$17,080
2.2.2.2	exterior column footings and piers-22 total @ (5x5x1.5+0.33x1.17x2.5)	32	cy	$120.00	$225.00	$345.00	$3,840	$7,200	$11,040
2.2.2.3	interior column footings and piers-14 total @ (3x3x1.25+1.17x1.17x1)	7	cy	$120.00	$225.00	$345.00	$840	$1,575	$2,415
2.2.2.4	exterior pier for ornamental brackets-22 total @ (1.83x1.33x3.00)	6	cy	$120.00	$225.00	$345.00	$720	$1,350	$2,070
2.2.2.5	elevator pit walls, miscellaneous pads, etc	6	cy	$150.00	$270.00	$420.00	$900	$1,620	$2,520
2.2.2.6	6" slab on grade for ground floor, including mesh reinforcing (109x49)	100	cy	$120.00	$135.00	$255.00	$12,000	$13,500	$25,500
2.2.2.7	4.25"elevated slab on metal deck for mezzanine, including reinforcing but not metal deck	44	cy	$150.00	$270.00	$420.00	$6,600	$11,880	$18,480
2.2.2.8	stairs-inside building	16	rs	$40.00	$101.25	$141.25	$640	$1,620	$2,260
2.2.2.9	landings for stairs	81	sf	$12.00	$18.00	$30.00	$972	$1,458	$2,430
2.2.2.99	SUBTOTAL: CONCRETE						$32,612	$51,183	$83,795
2.2.3	MASONRY								
2.2.3.1	8" insulated load bearing CMU-back-up on exterior wall	1,912	sf	$3.00	$5.40	$8.40	$5,736	$10,325	$16,061
2.2.3.2	4" face brick-exterior wall	1,912	sf	$5.00	$6.75	$11.75	$9,560	$12,906	$22,466
2.2.3.99	SUBTOTAL: MASONRY						$15,296	$23,231	$38,527

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.4	STRUCTURAL STEEL								
2.2.4.1	structural steel framing for roof, mezzanine and columns	38	tn	$1,400.00	$675.00	$2,075.00	$53,200	$25,650	$78,850
2.2.4.2	metal decking for mezzanine (1-1/2" composite, 20 ga)	3,340	sf	$2.00	$1.80	$3.80	$6,680	$6,012	$12,692
2.2.4.3	metal framing for roof (cold-rolled, 18 ga channel)	14,013	sf	$2.50	$1.80	$4.30	$35,033	$25,223	$60,256
2.2.4.4	handrail-perimeter of mezzanine	194	lf	$56.00	$4.50	$60.50	$10,864	$873	$11,737
2.2.4.5	ornamental ironwork-exterior brackets under eaves	22	ea	$1,200.00		$1,200.00	$26,400		$26,400
2.2.4.6	steel pan stair frame-for stairs	16		$120.00	$31.50	$151.50	$1,920	$504	$2,424
2.2.4.7	steel pan stair frame-for landings	81		$40.00	$9.00	$49.00	$3,240	$729	$3,969
2.2.4.99	SUBTOTAL: STRUCTURAL STEEL						$137,337	$58,991	$196,328
2.2.5	WOODS AND PLASTICS								
2.2.5.1	rough carpentry	1	ls	$10,000.00	$15,075.00	$25,075.00	$10,000	$15,075	$25,075
2.2.5.2	3/4" T&G plywood sheathing-roof deck	14,013	sf	$1.00	$0.68	$1.68	$14,013	$9,459	$23,472
2.2.5.3	bead board-interior ceiling and exterior eaves	9,407	sf	$2.00	$1.35	$3.35	$18,814	$12,699	$31,513
2.2.5.4	finish carpentry-trim	1	ls	$50,000.00		$50,000.00	$50,000		$50,000
2.2.5.5	base cabinets-ticketing area	33	lf	$200		$200.00	$6,600		$6,600
2.2.5.6	counter tops-ticketing area	33	lf	$60.00		$60.00	$1,980		$1,980
2.2.5.99	SUBTOTAL: WOODS AND PLASTICS						$101,407	$38,848	$138,640
2.2.6	THERMAL AND MOISTURE PROTECTION								
2.2.6.1	dampproofing and waterproofing	1	ls	$4,500.00		$4,500.00	$4,500		$4,500
2.2.6.2	wall insulation-6" fiberglass	1,968	sf	$0.35	$0.36	$0.71	$689	$708	$1,397
2.2.6.3	roof insulation-12" fiberglass	14,013	sf	$0.50	$0.36	$0.86	$7,007	$5,045	$12,051
2.2.6.4	rigid insulation-1-1/2" (interior face foundation walls-2.5x325.67)	814	sf	$0.40	$0.68	$1.08	$326	$549	$875
2.2.6.5	standing seam metal roof	12,294	sf	$3.50	$1.80	$5.30	$43,029	$22,129	$65,158
2.2.2.6	asphalt shingles for roof	1,719	sf	$0.25	$1.35	$1.60	$430	$2,321	$2,750
2.2.2.7	bit membrane under roof	14,013	sf	$0.35	$0.29	$0.64	$4,905	$4,099	$9,003
2.2.2.8	metal gutter	756	lf	$2.00	$4.50	$6.50	$1,512	$3,402	$4,914
2.2.2.9	metal downspout and leader	250	lf	$2.00	$2.25	$4.25	$500	$563	$1,063
2.2.2.10	roof flashing and trim	1,000	sf	$5.00	$6.75	$11.75	$5,000	$6,750	$11,750
2.2.2.11	caulking and sealants	1	ls	$12,000.00		$12,000.00	$12,000		$12,000
2.2.6.99	SUBTOTAL: THERMAL AND MOISTURE PROTECTION						$79,896	$45,566	$125,462
2.2.7	DOORS AND WINDOWS								
2.2.7.1	3'-0" hollow metal door, including hardware	21	ea	$750.00	$180.00	$930.00	$15,750	$3,780	$19,530
2.2.7.2	6'-0" automatic sliding glass doors (including 8'x12' painted metal storefront frame, glass, hardware, electric openers, etc.)	5	ea	$9,200.00	$1,800.00	$11,000.00	$46,000	$9,000	$55,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.7.3	6' high bulletproof glass (exterior wall of ticketing area)	122	sf	$50.00	$9.00	$59.00	$6,100	$1,098	$7,198
2.2.7.4	7'hx12'w roll-up grilles (manual operation)	4	ea	$2,500.00	$360.00	$2,860.00	$10,000	$1,440	$11,440
2.2.7.5	6' glass wall (interior wall of ticketing area)	60	sf	$25.00	$9.00	$34.00	$1,500	$540	$2,040
2.2.7.6	4'x4' custom wood window/awning	25	ea	$640.00	$90.00	$730.00	$16,000	$2,250	$18,250
2.2.7.7	6'x4' custom wood window/awning	2	ea	$960.00	$90.00	$1,050.00	$1,920	$180	$2,100
2.2.7.8	3.5'x4' custom wood window/awning	47	ea	$560.00	$90.00	$650.00	$26,320	$4,230	$30,550
2.2.7.9	7'x4' custom wood/awning	1	ea	$1,120.00	$90.00	$1,210.00	$1,120	$90	$1,210
2.2.7.10	3'x3' wood window/awning (interior at mezzanine)	42	ea	$200.00	$45.00	$245.00	$8,400	$1,890	$10,290
2.2.7.11	4'x3' custom wood window/awning	54	ea	$480.00	$90.00	$570.00	$25,920	$4,860	$30,780
2.2.7.12	semicircle window at front of peak	1	ea	$1,500.00	$180.00	$1,680.00	$1,500	$180	$1,680
2.2.7.99	SUBTOTAL: DOORS AND WINDOWS						$160,530	$29,538	$190,068
2.2.8	FINISHES								
2.2.8.1	4" metal studs-25 gauge	1,904	sf	$0.45	$0.90	$1.35	$857	$1,714	$2,570
2.2.8.2	8" metal studs-18 gauge	2,744	sf	$2.50	$0.90	$3.40	$6,860	$2,470	$9,330
2.2.8.3	1/2" gypboard	7,064	sf	$0.20	$0.90	$1.10	$1,413.00	$6,358	$7,770
2.2.8.4	1/2" gypboard sheathing	139	sf	$0.20	$0.90	$1.10	$28	$125	$153
2.2.8.5	porcelean ceramic tile-floor	3,325	sf	$6.50	$3.15	$9.65	$21,613	$10,474	$32,086
2.2.8.6	porcelean ceramic tile-toiletroom walls	1,316	sf	$4.50	$3.15	$7.65	$5.92	$4,145	$10,067
2.2.8.7	ceiling grid	1,232	sf	$1.50	$0.90	$2.40	$1,848	$1,109	$2,957
2.2.8.8	carpeting-commercial grade, no pad (bus waiting and ticketing areas on ground floor, offices on mezzanine level)	188	sy	$35.00		$35.00	$6,580		$6,580
2.2.8.9	painting-latex on drywall (primer+2 coats)	7,064	sf	$0.12	$0.45	$0.57	$848	$3,179	$4,026
2.2.8.10	painting-wood trim	5,000	lf	$0.12	$0.90	$1.02	$600	$4,500	$5,100
2.2.8.11	painting-acrylic urethane	9,407	sf	$0.30	$0.45	$0.75	$2,822	$4,233	$7,055
2.2.8.12	painting-underside of mezzanine	3,340	sf	$0.12	$0.45	$0.57	$401	$1,503	$1,904
2.2.8.13	wallcovering	1	ls	$1,200.00		$1,200.00	$1,200		$1,200
2.2.8.99	SUBTOTAL: FINISHES						$50,990	$39,809	$90,799
2.2.9	SPECIALTES								
2.2.9.1	toilet partitions-painted metal, ceiling hung, including hardware	1	ls	$4,810.00		$4,810.00	$4,810.00		$4,810
2.2.9.2	toiletroom accessories (mirrors, soap dispensers, towel dispensers)	1	ls	$2,450.00		$2,450.00	$2,450.00		$2,450
2.2.9.3	toiletroom marble countertops	14	lf	$200.00		$200.00	$2,800.00		$2,800
2.2.9.4	miscellaneous specialties	1	ls	$13,060.00		$13,060.00	$13,060.00		$13,060
2.2.9.99	SUBTOTAL: SPECIALTIES						$23,120		$23,120
2.2.10	FURNISHINGS								
2.2.10.1	type 2 wooden benches-interior, main lobby	3	ea	$800.00	$90.00	$890.00	$2,400	$270	$2,670

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.10.2	airport type seating-interior, bus waiting area	52	ea	$360.00	$101.25	$461.25	$18,720	$5,265	$23,985
2.2.10.99	SUBTOTAL: FURNISHINGS						$21,120	$5,535	$26,655
2.2.11	CONVEYING SYSTEMS								
2.2.11.1	elevator-pitless hydraulic, 2-story, completely installed	1	ls	$48,940.00		$48,940.00	$48,940		$48,940
2.2.11.99	SUBTOTAL: CONVEYING SYSTEMS						$48,940		$48,940
2.2.12	MECHANICAL/HVAC								
2.2.12.1	hydronic heating system-1000 MBH gas boiler	9,600	sf	$4.00	$4.50	$8.50	$38,400	$43,200	$81,600
2.2.12.2	split system air cooled-25 ton	9,600	sf	$4.50	$4.50	$9.00	$43,200	$43,200	$86,400
2.2.12.3	toiletroom ventilation	4	ea	$1,000.00	$1,080.00	$2,080.00	$4,000	$4,320	$8,320
2.2.12.4	electric hot water heater (80 gal.)-including all connections, valves, etc	1	ea	$780.00	$720.00	$1,500.00	$780	$720	$1,500
2.2.12.99	SUBTOTAL: MECHANICAL/HVAC						$86,380	$91,440	$177,820
2.2.13	PLUMBING/FIRE PROTECTION								
2.2.13.1	storm drain piping	300	lf	$5.00	$14.85	$19.85	$1,500	$4,455	$5,955
2.2.13.2	water supply piping	600	lf	$4.00	$5.63	$9.63	$2,400	$3,375	$5,775
2.2.13.3.	waste and drain piping-4"PVC	450	lf	$5.00	$14.85	$19.85	$2,250	$6,683	$8,933
2.2.13.4	vending machine piping	1	ls	$600.00	$720.00	$1,320.00	$600	$720	$1,320
2.2.13.5	wall hung toilets	6	ea	$700.00	$450.00	$1,150.00	$4,200	$2,700	$6,900
2.2.13.6	wall hung urinals	2	ea	$600.00	$450.00	$41,050.00	$1,200	$900	$2,100
2.2.13.7	wall hung water cooler	1	ea	$700.00	$360.00	$1,060.00	$700	$360	$1,060
2.2.13.8	wall hung lavoratories	5	ea	$550.00	$450.00	$1,000.00	$2,750	$2,250	$5,000
2.2.13.9	wall hung janitor sink	1	ea	$600.00	$360.00	$4,960.00	$600	$360	$960
2.2.13.10	rough-in for food area	1	ea	$500.00	$450.00	$950.00	$4,500	$450	$950
2.2.13.11	sprinkler system, wet type, ordinary hazard (interior of Station Building only)	8,200	sf	$1.26	$1.17	$2.43	$10,332	$9,594	$19,926
2.2.13.99	SUBTOTAL: PLUMBING/FIRE PROTECTION						$27,032	$31,847	$58,879
2.2.14	ELECTRICAL								
2.2.14.1	HVAC power distribution panelboard	1	ls	$4,150.00		$4,150.00	$4,150		$4,150
2.2.14.2	30kVA distribution transformer-station power and lighting	1	ls	$2,063.00		$2,063.00	$2,063		$2,063
2.2.14.3	225A station power and lighting panelboard	1	ls	$4,270.00		$4,270.00	$4,270		$4,270
2.2.14.4	tenant panelboard transformer and meters (4)	1	ls	$7,300.00		$7,300.00	$7,300		$7,300
2.2.14.5	tenant panelboard transformer and meters (4)	1	ls	$9,400.00		$9,400.00	$9,400		$9,400
2.2.14.6	track heater power distribution panelboard	1	ls	$5,324.00		$5,324.00	$5,324		$5,324
2.2.14.7	parking area and lighting panelboard	1	ls	$3,265.00		$3,265.00	$3,265		$3,265
2.2.14.8	exhaust fan-including wiring	1	ls	$6,037.00		$6,037.00	$6,037		$6,037

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.14.9	cabinet heater-including wiring and terminations	1	ls	$4,512.00		$4,512.00	$4,512		$4,512
2.2.14.10	electric service for air conditioning unit	1	ls	$1,013.00		$1,013.00	$1,013		$1,013
2.2.14.11	electric service for hot water pump	1	ls	$3,153.00		$3,153.00	$3,153		$3,153
2.2.14.12	electric service for hot water boiler	1	ls	$921.00		$921.00	$921		$921
2.2.14.13	electric service for tennant roll-up grille-RG 1A, RG 2B, RG 3C, RG 4D	1	ls	$3,344.00		$3,344.00	$3,344		$3,344
2.2.14.14	electric service for electric door-south, east, north, and west vestibules	1	ls	$3,528.00		$3,528.00	$3,528		$3,528
2.2.14.15	illuminated signage	1	ls	$825.00		$825.00	$825		$825
2.2.14.16	station building-grounding subgrade	1	ls	$1,575.00		$1,575.00	$1,575		$1,575
2.2.14.17	metering switch board	1	ls	$11,100.00	$1,080.00	$12,180.00	$11,100	$1,080	$12,180
2.2.14.18	equipment grounding (to be reviewed)	1	ls	$930.00		$930.00	$930		$930
2.2.14.19	electric service	1	ls	$2,000.00	$1,920.00	$3,920.00	$2,000	$1,920	$3,920
2.2.14.20	hanging pendant lights-main lobby and seating area	7	ea	$500.00	$204.00	$704.00	$3,500	$1,428	$4,928
2.2.14.21	2x2 flourescent lights with grid	20	ea	$200.00	$120.00	$320.00	$4,000	$2,400	$6,400
2.2.14.22	perforated pendant flourescent light on mezzanine	16	ea	$150.00	$96.00	$246.00	$2,400	$1,536	$3,936
2.2.14.23	surface mounted ceiling fixtures under eaves	26	ea	$120.00	$58.50	$178.50	$3,120	$1,521	$4,641
2.2.14.24	wall sconces in lobby	16	ea	$85.00	$33.75	$118.75	$1,360	$540	$1,900
2.2.14.25	2x4 flourescent lights with grid	6	ea	$300.00	$146.25	$446.25	$1,800	$878	$2,678
2.2.14.26	conduit and wire allowance	1	ls	$5,000.00	$18,000.00	$23,000.00	$5,000	$18,000	$23,000
2.2.14.27	lighting allowance for emergency and exit lights	1	ls	$5,000.00	$2,700.00	$7,700.00	$5,000	$2,700	$7,700
2.2.14.28	communications system for building (telephone, public addree, etc.)	1	ls	$77,538.00		$77,538.00	$77,538		$77,538
2.2.14.29	fire alarm system for building (smoke detectors, annunciation panel, etc.)	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.2.14.99	SUBTOTAL: ELECTRICAL						$198,428	$32,003	$230,431
2.2.99	**SUBTOTAL: STATION BUILDING-SCHEME 1 (RECTANGULAR)**						**$1,005,492**	**$446,375**	**$1,451,867**
2.99	**TOTAL: SITE SIDE CONSTRUCTION**						**$4,409,530**	**$707,573**	**$5,117,103**

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Jun 1998)

FINAL DESIGN - OPTIONS AT 30% FOR REDUCTION OF CONSTRUCTION COST (Revised for Actions Taken at Meeting on August 12, 1998)

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1	OPTIONS FOR SITEWORK COST REDUCTIONS								
Option 2.1-1 - Allocate Emergency Power Costs to MBTA R.O.W. Costs									
2.1.8.5	(deduct) emergency power-125kw diesel generator set (480/277v, 3ph, 3w, 60hz, 3ph sensing)	1	ls	$63,000.00		$63,000	$63,000		$63,000
2.1.8.6	(deduct) emergency power-diesel generator output cables (3-1/c#300mcm, 600v, xlp w/ grd#3awg)-(13'coil+85'u.g.+12'coil=110'/cablex3cables=330')	330	lf	$12.50	$3.60	$16.10	$4,125	$1,188	$5,313
2.1.8.7	(deduct) emergency power-automatic transfer bypass/isolation switch	1	ea	$12,000.00	$1,800.00	$13,800.00	$12,000	$1,800	$13,800
2.1.8.8	(deduct) emergency power-terminations, 600v compression type lugs	1	ls	$1,025.00		$1,025.00	$1,025		$1,025
							Net Reduction in Cost=		$83,138
Option 2.1-2 - Delete Concrete Edge Strip Along Curblines in Lawn Areas									
2.1.6.4	(deduct) concrete edge strip (along curbline of planted areas abutting heavily travelled roadways	1,500	lf	$6.00		$6.00	$9,000		$9,000
							Net Reduction in Cost=		$9,000
Option 2.1-3 Reduce the Amount of Time Assumed for Siteside Environmental Services From 480 Hours to 200 Hours (Establish complection times in specs)									
2.1.11.1	(deduct) LSP on-site during critical earthwork operations (delete 280 hours, leaving 200 hours)	1	ls	$28,000.00		$28,000.00	$28,000		$28,000
2.1.11.2	(deduct) laboratoty testing services (reduce by $3000)	1	ls	$3,000.00		$3,000.00	$3,000		$3,000
							Net Reduction in Cost=		$31,000
Option 2.1-4 - Eliminate median strip island from busway, and from main access road (keep busway width as 100', roadway width as 45')									
2.1.2.1	(deduct 4" thick concrete sidewalk (11'x140'+104=1644sf)+(4'x190'=760sf)	2,404	sf	$3.00		$3.00	$7,212		$7,212
2.1.2.6	(add) Class I bituminous concrete pavement-1 1/2" top, 1-1/2" binder, 3" base course for HD pave	106	tn	$32.00		$32.00	$3,392		$3,392
2.1.2.7	(deduct) vertical granite curbing-straight (2x140'+2x19'=318')+(2x190'=380')	698	lf	$18.53		$18.53	$12,934		$12,934
2.1.2.10	(add) 4" wide pavement striping-yellow (2x140'+2x19'+140x17'=2698')+(2x190'=380')	3,078	lf	$0.25		$0.25	$770		$770
							Net Reduction in Cost=		$15,984
Option 2.1-5 - Reduce Width of Main Access Road From 45' to 32', Increase Long-Term Parking by 10 Spaces									
2.1.2.5	(deduct) Class I bituminous concrete pavement (base course, 3" at heavy duty sections)	83	tn	$32.00		$32.00	$2,656		$2,656
2.1.2.6	(deduct) Class I bituminous concrete pavement (1-1/2" top course, 1-1/2" binder course at HD sect)	83	tn	$32.00		$32.00	$2,656		$2,656
2.1.2.6	(add) Class I bituminous concrete pavement (1-1/2" top course, 2-1/2" binder course at std duty sec)	111	tn	$32.00		$32.00	$3,552		$3,552
2.1.2.10	(ad) 4" wide pavement striping-yellow	255	lf	$0.25		$0.25	$64		$64

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
							Net Reduction in Cost=		$1,696
Option 2.1-6 Delete Decorative Sidewalk (Use Regular Concrete Sidewalk) Around Building									
2.1.2.1	(add) 4" thick concrete sidewalks	3,000	sf	$3.00		$3.00	$9,000		$9,000
2.1.2.2	(deduct) 4" thick concrete sidewalks, with decorative finish	3,000	sf	$4.00		$4.00	$12,000		$12,000
							Net Reduction in Cost=		$3,000
Option 2.1-7 - Delete Irrigation System (Note: this option not accepted)									
2.1.7.1	(deduct) irrigation system	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
							Net Reduction in Cost=		$20,000
Option 2.1-8 Add Roadway Lighting Along Sidewalk Adjacent to Tracks									
2.1.8.25	(add) Type S2 single roadway lighting-30' tapered steel pole w/single davit-installed	3	ls	$700.00	$465.00	$1,165.00	$2,100	$1,395	$3,495
2.1.8.26	(add) Type S2 single roadway lighting-foundation for 30'pole	3	ea	$600.00		$600.00	$1,800		$1,800
2.1.8.27	(add) Type S2 single roadway lighting-250w fixture (mounted 1 each on 30' pole)installed	3	ls	$500.00	$160.00	$660.00	$1,500	$480	$1,980
							Net Increase in Cost=		$7,275
Option 2.1-9 - Limit Pedestrian Light Poles to Building & Plaza Only, Increase Roadway Light Poles Accordingly									
2.1.8.19	(deduct) Type S4 pedestrian lighting-14' decorative steel light pole -installed	12	ls	$1,500.00	$115.00	$1,615.00	$18,000	$1,395	$19,380
2.1.8.20	(deduct) Type S4 pedestrian lighting-foundation for 14' pole	12	ea	$400.00		$400.00	$4,800		$4,800
2.1.8.21	(deduct) Type S4 pedestrian lighting-100w fixture w/bracket arm (mounted 1 each on 14' pole)	12	ls	$600.00	$170.00	$770.00	$7,200	$2,040	$9,240
2.1.8.25	(add) Type S2 single roadway lighting-30' tapered steel pole w/single davit -installed	5	ls	$700.00	$465.00	$1,165.00	$3,500	$2,325	$5,825
2.1.8.26	(add) Type S2 single roadway lighting-foundation for 30' pole	5	ea	$600.00		$600.00	$3,000		$3,000
2.1.8.27	(add) Type S2 single roadway lighting-250w fixture (mounted 1 each on 30' pole)-installed	5	ls	$500.00	$160.00	$660.00	$2,500	$800	$3,300
							Net Reduction in Cost=		$21,295
Option 2.1-10 - Increase Height of Light Poles Along Daily Parking Driveway and Presidential Way From 30' to 40', Spacing to 160'									
2.1.8.25	(deduct) Type S2 single roadway lighting-30' tapered steel pole w/single davit-installed	22	ls	$700.00	$465.00	$1,165.00	$15,400	$10,230	$25,630
2.1.8.26	(deduct) Type S2 single roadway lighting-foundation for 30' pole	22	ea	$600.00		$600.00	$13,200		$13,200
2.1.8.27	(deduct) Type S2 single roadway lighting-250w fixture (mounted 1 each on 30' pole)-installed	22	ls	$500.00	$160.00	$660.00	$11,000	$3,520	$14,520
2.1.8.25	(add) Type S2-A single roadway lighting-40' tapered steel pole w/single davit-installed	20	ls	$800.00	$500.00	$1,300.00	$16,000	$10,000	$26,000
2.1.8.26	Type S2-A single roadway lighting-foundation for 40' pole	20	ea	$650.00		$650.00	$13,000		$13,000
2.1.8.27	(add) Type S3-A single roadway lighting-250w fixture (mounted 1 each on 40' pole)-installed	20	ls	$500.00	$160.00	$660.00	$10,000	$3,200	$13,200
							Net Reduction in Cost=		$1,150

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
Option 2.1-11A - Change Fixtures on Type S1 100' Poles From (8) 400w to (4) 1000w (Note: This option not accepted)									
2.1.8.30	(deduct) Type S1 parking lot lighting-400w fixture (mounted 8 each on 100' pole)-installed	72	ls	$500.00	$110.00	$610.00	$36,000.00	$7,920	$43,920
2.1.8.30	(add) Type S1-A parking lot lighting-1000w fixture (mounted 4 each on 100' pole)-installed	36	ls	$700.00	$130.00	$830.00	$25,200.00	$4,680	$29,880
							Net Reduction in Cost=		$14,040
Option 2.1-11B - Change From Type S1 100' Poles w/ (8) 400w to Type S2A 40' Single Poles w/ (1) 250w and Type S2B 40' Double Poles w/ 250w									
2.1.8.28	(deduct) Type S1 parking lot lighting-100'highmast pole-installed	9	ea	$8,000.00	$1,240.00	$9,240.00	$72,000	$11,160	$83,160
2.1.8.29	(deduct) Type S1 parking lot lighting-foundation for 100'pole	9	ea	$1,500.00		$1,500.00	$13,500		$13,500
2.1.8.30	(deduct) Type S1 parking lot lighting-400w fixture (mounted 8 each on 100' pole)-installed	72	ea	$500.00	$110.00	$610.00	$36,000	$7,920	$43,920
2.1.8.25	(add) Type S2-A single roadway lighting-40' tapered steel pole w/single davit-installed	14	ls	$800.00	$500.00	$1,310.00	$11,200	$7,000	$18,200
2.1.8.26	(add) Type S2-A single roadway lighting-foundation for 40' pole	14	ea	$650.00		$650.00	$9,100		$9,100
2.1.8.27	(add) Type S2-A single roadway lighting-250w fixture (mounted 1 each on 40' pole)-installed	14	ls	$500.00	$160.00	$660.00	$7,000	$2,240	$9,240
2.1.8.25	(add) Type S2-B double roadway lighting-40'tapered steel pole w/ double davit-installed	27	ls	$800.00	$500.00	$1,300.00	$21,600	$13,500	$35,100
2.1.8.26	(add) Type S2-B double roadway lighting-foundation for 40' pole	27	ea	$650.00		$650.00	$17,550		$17,550
2.1.8.27	(add) Type S2-B double roadway lighting-250w fixture (mounted 2 each on 40' pole)-installed	54	ls	$500	$160.00	$660.00	$27,000	$8,640	$35,640
							Net Reduction in Cost=		$15,750
Option 2.1-12 - Reduce Local Bus Canopy from 168' to 96'; Reduce Logan Express Canopy from 168' to 96; Reduce Van-Pool Canopy from 2 at 48' to 1 at 48'									
2.1.10.1	(deduct) Site canopies at bus platforms-(12'x72'half-canopies at local bus berths)+(12'x72'half-canopies at Logan Express bus berths	1,728	sf	$35.00		$35.00	$60,480		$60,480
2.1.10.2	(deduct) Site canopies at park-and-ride platforms-(12'x48'half-canopies at van loading areas)	576	sf	$35.00		$35.00	$20,160		$20,160
							Net Reduction in Cost=		$80,640
Option 2.1-13A - Substitute Type VB Vertical Granite Curbing For Type VA-4 Vertical Granite Curbing; and Use Sloped Granite Along Non-Sidewalk Areas									
2.1.2.7	(deduct) Type VA-4 vertical granite curbing-straight	5,500	lf	$18.53		$18.53	$101,915		$101,915
2.1.2.8	(deduct) Type VA-4 vertical granite curbing-curved	1,300	lf	$23.90		$23.90	$31,070		$31,070
2.1.2.7	(add) Type VB vertical granite curbing-straight	3,800	lf	$16.09		$16.09	$61,142		$61,142
2.1.2.8	(add) Type VB vertical granite curbing-curved	960	lf	$22.39		$22.39	$21,494		$21,494
2.1.2.9	(add) sloped granite curbing	2,040	lf	$11.00		$11.00	$22,440		$22,440
							Net Reduction in Cost=		$50,349
Option 2.1-13B - Substitute Vertical Pre-Cast Curbing For Type VA-4 Vertical Granite Curbing (Note: This option not accepted)									
2.1.2.7	(deduct) vertical granite curbing-straight	5,500	lf	$18.53		$18.53	$101,915		$101,915
2.1.2.8	(deduct) vertical granite curbing-curved	1,300	lf	$23.90		$23.90	$31,070		$31,070

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.2.7	(add) vertical precast concrete curbing-straight	5,500	lf	$10.70		$10.70	$58,850		$58,850
2.1.2.8	(add) vertical precast concrete curbing-curved	1,300	lf	$16.65		$16.65	$21,645		$21,645
							Net Reduction in Cost=		$52,490
Option 2.1-14A - Reduce the Number of Master Meter Pay Stations in Daily Parking Area (Note: This option on "HOLD" pending option 15)									
2.1.9.1	(deduct) master meter pay stations-delete 1 near van platform, and 1 in Station Building	2	ea	$8,000.00	$1,080.00	$9,080.00	$16,000	$2,160	$18,160
							Net Reduction in Cost=		$18,160
Option 2.1-14B - Re-Use Traffic Control Equipment From Mishawum Logan Express Station (Note: This option on "HOLD" pending option 15)									
2.1.9.3	(deduct) parking gate-for long-term parking lot (2 inbound lanes, 2 outbound lanes)	4	ea	$3,500.00	$450.00	$3,950.00	$14,000	$1,800	$15,800
2.1.9.4	(deduct) ticket dispenser (machine readable)-for long-term parking lot (2 inbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
							Net Reduction in Cost=		$42,800
Option 2.1-15 Parking Operator to Provide Parking Equipment with Agency Option to Buy at End of Lease									
2.1.9.1	(deduct) master meter pay stations-for users of daily parking lot (4 located along track sidewalk, 2 near van platform, and 2 in Station Building)	8	ea	$8,000.00	$1,080.00	$9,080.00	$64,000	$8,640	$72,640
2.1.9.2	(deduct) pay-on-foot cantral cashier station-for users of long-term parking lot (read ticket, calculate fee, accept payment, validate ticket, send data to computer	1	ea	$60,000.00	$4,800.00	$64,800.00	$60,000	$4,800	$64,800
2.1.9.3	(deduct) parking gate-for long-term parking lot (2 inbound lanes, 2 outbound lanes)	4	ea	$3,500.00	$450.00	$3,950.00	$14,000	$1,800	$15,800
2.1.9.4	(deduct) ticket dispenser (machine readable)-for long-term parking lot (2 inbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.5	(deduct) validated ticket reader (machine readable)- for long-term parking lot (2 outbound lanes)	2	ea	$12,000.00	$1,440.00	$13,440.00	$24,000	$2,880	$26,880
2.1.9.6	(deduct) fee computer (ticket counter cashier terminal, tied-in to pay-on-foot unit)	1	ea	$10,000.00	$1,080.00	$11,080.00	$10,000	$1,080	$11,080
2.1.9.7	(deduct) detector loops (2 each, at each inbound and outbound gates)	8	ea	$500.00	$180.00	$680.00	$4,000	$1,440	$5,440
2.1.9.8	(deduct) computer (network for master meters/pay-on-foot/cashier)	1	ea	$4,000.00	$540.00	$4,540.00	$4,000	$540	$4,540
2.1.9.9	(deduct) computer software-including training	1	ea	$6,000.00	$720.00	$6,720.00	$6,000	$720	$6,720
							Net Reduction in Cost=		$234,780
Option 2.1-16 - Defer construction of 406 parking spaces (115,500s.f.) at north end of daily parking lot (Note: This option not accepted)									
2.1.1.5	(deduct) fine grading	12,833	sy	$1.12		$1.12	$14,373		$14,373
2.1.1.6	(deduct) gravel borrow for filling to subgrade (including 25% for compaction as per MHD guidelines)	4,275	cy	$8.61		$8.61	$36,808		$36,808
2.1.2.6	(deduct) Class I bituminous concrete pavement (1-1/2" top course, 2-1/2" binder course)	2,880	tn	$32.00		$32.00	$92,160		$92,160
2.1.2.9	(deduct) slope granite curbing	700	lf	$11.00		$11.00	$7,700		$7,700

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.5.4	(deduct) steel guardrail and post, highway type	350	lf	$13.00		$13.00	$4,550		$4,550
2.1.8.28	(deduct) Type S1 parking lot lighting-100'highmast pole-installed	1	ea	$8,000.00	$1,240.00	$9,240.00	$8,000	$1,240	$9,240
2.1.8.29	(deduct) Type S1 parking lot lighting-foundation for 100' pole	1	ea	$1,500.00		$1,500.00	$1,500		$1,500
2.1.8.30	(deduct) Type S1 parking lot lighting-400w fixture (mounted 8 each on 100' pole)-installed	8	ea	$500.00	$110.00	$610.00	$4,000	$880	$4,880
							Net Reduction in Cost=		$171,211
Option 2.1-17 Defer construction of 100 parking spaces (40,000s.f.) at south end of long-term parking lot (Note: This option not accepted)									
2.1.1.5	(deduct) fine grading	4,444	sy	$1.12		$1.12	$4,977		$4,977
2.1.1.6	(deduct) gravel borrow for filling to subgrade (including 25% for compaction as per MHD guidelines)	880	cy	$8.61		$8.61	$7,577		$7,577
2.1.2.6	(deduct) Class I bituminous concrete pavement (1-1/2" top course, 2-1/2" binder course)	1,000	tn	$32.00		$32.00	$32,000		$32,000
2.1.2.9	(deduct) slope granite curbing	325	lf	$11.00		$11.00	$3,575		$3,575
2.1.5.4	(deduct) steel guardrail and post, highway type	285	lf	$13.00		$13.00	$3,705		$3,705
2.1.8.28	(deduct) Type S1 parking lot lighting-100'highmast pole-installed	1	ea	$8,000.00	$1,240.00	$9,240	$8,000	$1,240	$9,240
2.1.8.29	(deduct) Type S1 parking lot lighting-foundation for 100' pole	1	ea	$1,500.00		$1,500.00	$1,500		$1,500
2.1.8.30	(deduct) Type S1 parking lot lighting-400w fixture (mounted 8 each on 100' pole)-installed	8	ea	$500.00	$110.00	$610.00	$4,000	$880	$4,880
							Net Reduction in Cost=		$67,454
Option 2.1-18 - Reduce the Number of Trees from 95 to 80									
2.1.6.6	(deduct) trees in allees (3" to 3.5" caliper, staked and guyed)	15	ea	$800.00		$800.00	$12,000		$12,000
							Net Reduction in Cost=		$12,000
Option 2.1-19 - Assume Boston Edison Furnishes/Installs and Owns Primary Transformer (Note: This option on "HOLD" pending confirmation by BECO)									
2.1.8.1	(deduct) normal power-500kVA pad mounted transformer (by BECO)	1	ea	$26,000.00	$4,320.00	$30,320.00	$26,000	$4,320	$30,320
							Net Reduction in Cost=		$30,320
TOTAL OF OPTIONS FOR SITEWORK COST REDUCTIONS							Total Net Reduction in Cost for Sitework Options (7,11A,13B,14A,14B,16,17,19 not incl.)=		$552,507
							Site Costs at 30% Estimate=		$3,665,236
							Site Costs With Options Accepted 8-12-98=		$3,112,729

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Aug 1998)

FINAL DESIGN - OPTIONS AT 30% FOR
REDUCTION OF CONSTRUCTION COST
(Revised for Actions Taken at Meeting on August 12, 1998)

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
	2.1 OPTIONS FOR STATION BUILDING COST REDUCTIONS								
	Option 2.2-1 Allocate Emergency Power Costs to MBTA R.O.W. Costs								
2.2.14.6	(deduct) track heater power distribution panelboard	1	ls	$5,324.00		$5,324.00	$5,324		$5,324
							Net Reduction in Cost=		$5,324
	Option 2.2-2 - Delete Liner and Vapor Collection System From Under Building								
2.2.1.2	(deduct) impervious liner under building, wrap up exterior of fdn wall (121.0x52.0)	6,292	sf	$2.00		$2.00	$12,584		$12,584
2.2.1.4	(deduct) 4" perforated PVC pipe under slab for vapor collection (8x49.33+1x116.50)	512	lf	$10.00		$10.00	$5,120		$5,120
							Net Reduction in Cost=		$17,704
	Option 2.2-3 - Eliminate Lower Exterior Windows From Tenant Areas and Cash Room/Toilet								
2.2.7.6	(deduct) 4'x4' custom wood window/awning	7	ea	$640.00	$90.00	$730.00	$4,480	$630	$5,110
2.2.3.1	(add) 8" insulated load bearing CMU-back-up on exterior wall (4'x4'each window)	112	sf	$3.00	$5.40	$8.40	$336	$605	$941
2.2.3.2	(add) 4" face brick-exterior wall (4'x4' each window)	112	sf	$5.00	$6.75	$11.75	$560	$756	$1,316
							Net Reduction in Cost=		$2,853
	Option 2.2-4 - Change Exterior Windows From Custom to Standard Units (Vinyl Clad Stationary Units, Low E, w/Argon), and Reduce the Number of Units								
2.2.7.6	(deduct) 4'x4' custom wood window/awning	25	ea	$640.00	$90.00	$730.00	$16,000	$2,250	$18,250
2.2.7.7	(deduct) 6'x4' custom wood window/awning	2	ea	$960.00	$90.00	$1,050.00	$1,920	$180	$2,100
2.2.7.8	(deduct) 3.5'x4' custom wood window/awning	47	ea	$560.00	$90.00	$650.00	$26,320	$4,230	$30,550
2.2.7.9	(deduct) 7'x4' custom wood window/awning	1	ea	$1,120.00	$90.00	$1,210.00	$1,120	$90	$1,210
2.2.7.10	(deduct) 3'x3' wood window/awning (interior at mezzanine)	42	ea	$200.00	$45.00	$245.00	$8,400	$1,890	$10,290
2.2.7.11	(deduct) 4'x3' custom wood window/awning	54	ea	$480.00	$90.00	$570.00	$25,920	$4,860	$30,780
2.2.7.12	(deduct) semicircle window at front of peak	1	ea	$1,500.00	$180.00	$1,680.00	$1,500	$180	$1,680
2.2.7.6	(add) Type A-48"x48" at exterior wall mezzanine	28	ea	$709.00	$90.00	$799.00	$19,852	$2,520	$22,372
2.2.7.7	(add) Type B-48"x30" under eaves at exterior wall ground floor	36	ea	$598.00	$90.00	$688.00	$21,528	$3,240	$24,768
2.2.7.8	(add) Type C-30"x30" above sidelights of entry doors on sidewalls	4	ea	$396.00	$90.00	$486.00	$1,584	$360	$1,944
2.2.7.9	(add) Type D-60"x30" above door panels on sidewalla and sidelights and door panels on end wall	5	ea	$879.00	$135.00	$1,014.00	$4,395	$675	$5,070
2.2.7.10	(add) Type E-30"x48" at sides of peak windows on mezzanine	2	ea	$421.00	$45.00	$466.00	$842	$90	$932
2.2.7.11	(add) Type F-102"x48" peak window on mezzanine	1	ea	$3,072.00	$135.00	$3,207	$3,072	$135	$3,207
2.2.7.12	(add) Type G-102"x40" semi-circle window above peak window on mezzanine	1	ae	$3,497.00	$135.00	$3,632.00	$3,497	$135	$3,632
							Net Reduction in Cost=		$32,935
	Option 2.2-5 - Reduce Size of Roof Peak Over Entrance Door (back to face of Building)								
2.2.4.1	(deduct) structural steel framing for smaller (2x10ftx24lb/ft+2x10ftx40lb/ft)	0.7	tn	$1,400.00	$675.00	$2,075.00	$980	$473	$1,453

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.4.3	(deduct) cold-rolled metal framing for roof of peak (2x8ftx23ft+2x10ftx10ft=568sf)	568	sf	$2.50	$1.80	$4.30	$1,420	$1,022	$2,442
2.2.5.2	(deduct) 3/4" T&G plywood sheathing for roof of peak (2x8ftx23ft+2x10ftx10ft=568sf)	568	sf	$1.00	$0.68	$1.68	$568	$383	$951
2.2.5.3	(deduct) bead board for ceiling of peak (2x8ftx23ft+2x10ftx10ft=568sf)	568	sf	$2.00	$1.35	$3.35	$1,236	$767	$1,903
2.2.6.5	(deduct) standing seam metal roof of peak (2x8ftx23ft+2x10ftx10ft=568sf)	568	sf	$3.50	$1.80	$5.30	$1,988	$1,022	$3,010
2.2.6.7	(deduct) Bituthene membrane under standing seam roofing, for roof of peak	568	sf	$0.35	$0.29	$0.64	$199	$166	$365
							Net Reduction in Cost=		$10,124
Option 2.2-6 - Reduce Number of Ornamental Brackets From 22 to 8 (Note: This option on "HOLD" pending savings by cost reductions)									
2.2.2.4	(deduct) eliminate exterior conc fdn pier for ornamental brackets (14@1.83x1.33 x3.00)	4	cy	$120.00	$225.00	$345.00	$480	$900	$1,380
2.2.4.5	(deduct) ornamental ironwork-eliminate 14 exterior brackets under eaves	14	ea	$1,200.00		$1,200.00	$16,800		$16,800
							Net Reduction in Cost=		$18,180
Option 2.2-7 Use a lesser Detail for 8 Remaining Brackets (Note: This option not accepted)									
2.2.2.4	(deduct) eliminate exterior conc fdn pier for ornamental brackets (14@1.83x1.33 x3.00)	2	cy	$120.00	$225.00	$345.00	$240	$450	$690
2.2.4.5	(deduct) ornamental ironwork-use a lesser detail for 8 remaining exterior brackets under eaves	8	ea	$200.00		$200.00	$1,600		$1,600
							Net Reduction in Cost=		$2,290
Option 2.2-8 - Use 16" Wide Exterior Foundation Wall and Eliminate Pier at Columns									
2.2.2.1	(deduct) exterior foundation and dado walls (1x3x327.67) and footings (3x1x217.67)	61	cy	$100.00	$180.00	$280.00	$6,100	$10,980	$17,080
2.2.2.2	(deduct) exterior column footings and piers-22 total@(5x5x1.5+0.33x1.17x2.50)	32	cy	$120.00	$225.00	$345.00	$3,840	$7,200	$11,040
2.2.2.1	(add) exterior foundation and dado walls (1.33x3x327.67) and footings (3x1x217.67)	73	cy	$100.00	$144.00	$244.00	$7,300	$10,512	$17,812
2.2.2.2	(add) exterior column footings-22 total@(5x5x1.5)	31	cy	$120.00	$162.00	$282.00	$3,720	$5,022	$8,742
							Net Reduction in Cost=		$1,566
Option 2.2-9 - Reduce the Width of Eave Overhang From 10' to 8' (Note: This option on "HOLD" pending savings by cost reductions)									
2.2.4.1	(deduct) structural steel framing for support brackets at columns (22x2ftx30lb/ft)	0.7	tn	$1,400.00	$675.00	$2,075.00	$980	$473	$1,453
2.2.4.3	(deduct) cold-rolled metal framing for eave and soffit (2x402.67ftx2ft=1611sf)	1,611	sf	$2.50	$1.80	$4.30	$4,028	$2,900	$6,927
2.2.5.2	(deduct) 3/4" T&G plywood sheathing for roof of eave (402.67ftx2ft=805sf)	805	sf	$1.00	$0.68	$1.68	$805	$543	$1,348
2.2.5.3	(deduct) bead board for soffit (402.67ftx2ft=805sf)	805	sf	$2.00	$1.35	$3.35	$1,610	$1,087	$2,697
2.2.6.5	(deduct) standing seam metal roof of eave (402.67ftx2ft=805sf)	805	sf	$3.50	$1.80	$5.30	$2,818	$1,449	$4,267
2.2.6.7	(deduct) Bituthene membrane under standing seamroofing, for roof of eave (402.67ftx2ft=805sf)	805	sf	$0.35	$0.29	$0.64	$282	$235	$517
							Net Reduction in Cost=		$17,209
Option 2.2-10 - Eliminate Soffit From Underside of Exterior Eave (Note: This option not accepted)									
2.2.3.2	(add) 4"face brick-exterior wall above soffit line (331.75x4.67+1,548sf)	1,548	sf	$5.00	$6.75	$11.75	$7,740	$10,449	$18,189
2.2.4.3	(deduct) cold-rolled metal framing for soffit (360.66ftx10ft=3607sf)	3,607	sf	$2.50	$1.80	$4.30	$9,018	$6,493	$15,510
2.2.5.3	(deduct) bead board for soffit (360.66ftx10ft=3607sf)	3,607	sf	$2.00	$1.35	$3.35	$7,214	$4,869	$12,083
2.2.5.3	(add) tounge and groove wood plank on underside of sloped roof(360.66ftx10.54ft= 3,802sf)	3,802	sf	$1.85	$1.35	$3.20	$7,034	$5,133	$12,166

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
							Net Reduction in Cost=		$2,762
Option 2.2-11 - Reduce Extent of Roof Gutters and Downspouts to Entrances Only (Note: This option not accepted									
2.2.6.8	(deduct) metal gutter	600	lf	$2.00	$4.50	$6.50	$1,200.00	$2,700	$3,900
2.2.6.9	(metal downspout and leader	150	lf	$2.00	$2.25	$4.25	$300	$338	$638
							Net Reduction in Cost=		$4,538
Option 2.2-12 - Simplify Roof Profile - Provide Straight Pitch From Peak to Edge (Note: This option not accepted)									
2.2.4.1	(deduct) structural steel framing for roof, mezzanine and columns	2	tn	$1,400.00	$675.00	$2,075.00	$2,800	$1,350	$4,150
2.2.4.3	(deduct) metal framing for roof (cold-rolled, 18 ga channel)	364	sf	$2.50	$1.80	$4.30	$910	$655	$1,565
2.2.5.2	(deduct) 3/4" T&G plywood sheathing-roof deck (12.67-10.50)(2x14.00x6)	364	sf	$1.00	$0.68	$1.68	$364	$246	$610
2.2.5.3	(deduct) bead board-interior ceilling	364	sf	$2.00	$1.35	$3.35	$728	$491	$1,219
2.2.6.3	(deduct) roof insulation-12"fiberglass	364	sf	$0.50	$0.36	$0.86	$182	$131	$313
2.2.6.5	(deduct) standing seam metal roof	364	sf	$3.50	$1.80	$5.30	$1,274	$655	$1,929
2.2.6.7	(deduct) bit membrane under roof	364	sf	$0.35	$0.29	$0.64	$127	$106	$234
							Net Reduction in Cost=		$10,020
Option 2.2-13 - Change Roofing From Standing Seam Metal to Asphalt Shingles									
2.2.6.5	(deduct) standing seam metal roof	12,294	sf	$3.50	$1.80	$5.30	$43,029	$22,129	$65,158
2.2.6.6	(add) asphalt shingles for roof	12,294	sf	$0.25	$1.35	$1.60	$3,074	$16,597	$19,670
							Net Reduction in Cost=		$45,488
Option 2.2-14 - Extend High Roof to End Wals; Use Hip Roof for High Roof; Use Windows in End Walls Instead of Dormers (Note: This option not accepted)									
2.2.3.1	(add) 8" insulated load bearing CMU-back-up on exterior wall (4)(8)(2x5.67+4x2)	619	sf	$3.00	$5.40	$8.40	$1,587	$3,343	$5,200
2.2.3.2	(add) 4" face brick-exterior wall (8x5x5.5)	619	sf	$5.00	$6.75	$11.75	$3,095	$4,178	$7,273
2.2.4.1	(deduct) structural steel framing for roof, mezzanine and columns	4	tn	$1,400.00	$675.00	$2,075.00	$5,600	$2,700	$8,300
2.2.4.3	(deduct) metal framing for roof (cold-rolled, 18 ga channel)	3,677	sf	$2.50	$1.80	$4.30	$9,193	$6,619	$15,811
2.2.5.2	(deduct) 3/4" T&G plywood sheathing-roof deck	3,677	sf	$1.00	$0.68	$1.68	$3,677	$2,482	$6,159
2.2.5.3	(deduct) bead board-interior ceiling and exterior eaves	3,000	sf	$2.00	$1.35	$3.35	$6,000	$4,050	$10,050
2.2.6.2	(add) wall insulation-8" fiber glass on mezannine level only	220	sf	$0.35	$0.36	$0.71	$77	$79	$156
2.2.6.3	(deduct) roof insulation-12"fiberglass	3,677	sf	$0.50	$0.36	$0.86	$1,839	$1,324	$3,162
2.2.6.5	(deduct) standing seam metal roof	3,677	sf	$3.50	$1.80	$5.30	$12,870	$6,619	$19,488
2.2.6.6	(deduct) asphalt shingles for roof	1,719	sf	$0.25	$1.35	$1.60	$430	$2,321	$2,750
2.2.6.7	(deduct) bit membrane under roof	3,677	sf	$0.35	$0.29	$0.64	$1,287	$1,076	$2,362
2.2.6.8	(deduct) metal gutter	64	lf	$2.00	$4.50	$6.50	$128	$288	$416
2.2.7.6	(add) 4'x4' custom wood window/awning	20	ea	$640.00	$90.00	$730.00	$12,800	$1,800	$14,600
							Net Reduction in Cost=		$41,270
Option 2.2-15 - Keep 2 Logan Express Entryways as Electric Doors, Change Other Entrywas to be Manual Leaf Doors Instead of Electric Sliding									
2.2.7.2	(deduct) 6'-0" automatic sliding glass doors (incuding 6'-10"x11'-10" painted metal storefront frame, glass, hardware, electric openers, etc.)	3	ea	$9,200.00	$1,800.00	$11,000.00	$27,600	$5,400	$33,000
2.2.7.2	(add) pair of 3'-0"x6'-8"glass leaf doors (incuding 6'-10"x11'-10" painted metal storefront frame, glass, hardware, electric openers, etc.)	3	ea	$8,000.00	$1,500.00	$9,500.00	$24,000	$4,500	$28,500

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.14.14	(deduct) electric service for electric door-north, and west vestibules	1	ls	$2,117.00		$2,117.00	$2,117		$2,117
							Net Reduction in Cost=		$6,617
Option 2.2-16 - Replace Interior "Barnsash" Windows in Lobby With Gypsum Board (Note: This option not accepted)									
2.2.7.10	(deduct) 3'x3' wood window/awning (interior at mezzanine)	42	ea	$200.00	$45.00	$245.00	$8,400	$1,890	$10,290
2.2.8.3	(add) 1/2" gypboard (42x3ftx3ft=378sf)	378	sf	$0.20	$0.90	$1.10	$76	$340	$416
2.2.8.9	(add) painting-latex on drywall (primer+2 coats)	378	sf	$0.12	$0.45	$0.57	$45	$170	$215
							Net Reduction in Cost=		$9,659
Option 2.2-17 - Replace Railing on Mezzanine With Railing Height Capped Gypsum Board on Steel Stud Partition (Note: This option not accepted)									
2.2.4.4	(deduct) handrail-perimeter of mezzanine	194	lf	$56.00	$4.50	$60.50	$10,864	$873	$11,737
2.2.5.4	(add) finish carpentry-trim (add finished wood cap rail 202' long)	1	ls	$3,000.00		$3,000.00	$3,000		$3,000
2.2.8.1	(add) 4" metal studs-25gauge (2)(12x14+20+14)+(3.33)(202.00/1.33)	763	sf	$0.45	$0.90	$1.35	$343	$687	$1,030
2.2.8.3	(add) 1/2" gypboard (2)(3.33)(12x14.00+20.00+14.00)	1,347	sf	$0.20	$0.90	$1.10	$269	$1,212	$1,482
2.2.8.9	(add) painting-latex on drywall (primer+2coats)	1,347	sf	$0.12	$0.45	$0.57	$162	$606	$768
							Net Reduction in Cost=		$5,457
Option 2.2-18 - Use Beadboard Plywood With Battens Instead of Beadboard for Ceiling of Main Roof (Note: This option not accepted)									
2.2.5.3	(deduct) bead board-interior ceiling and exterior eaves	9,407	sf	$2.00	$1.35	$3.35	$18,814	$12,699	$31,513
2.2.5.3	(add) bead board-soffit on exterior eaves	5,800	sf	$2.00	$1.35	$3.35	$11,600	$7,830	$19,430
2.2.5.3	(add) bead board plywood with battens-interior ceiling of main roof	3,607	sf	$1.50	$0.90	$2.40	$5,411	$3,246	$8,657
							Net Reduction in Cost=		$3,427
Option 2.2-19 - Use Gas-Fired Hot Air Heating system Instead of Gas-Fired Hydronic Heating System									
2.2.12.1	(deduct) hydronic heating system-1000MBH gas boiler	9,600	sf	$4.00	$4.50	$8.50	$38,400	$43,200	$81,600
2.2.12.1	(add) gas-fired hot air heating system	9,600	sf	$3.00	$2.25	$5.25	$28,800	$21,600	$50,400
							Net Reduction in Cost=		$31,200
Option 2.2-20 - Re-Use of Existing Airport Seating From Mishawum Logan Express Station (Note: re-use subject to inspection, quantity to be verified)									
2.2.10.2	(deduct) airport type seating-interior, bus waiting area	52	ea	$360.00	$101.25	$461.25	$18,720	$5,265	$23,985
2.2.10.2	(add) remove and refurbish airport type seating from Mishawum, re-install at RTC	52	ea		$112.50	$112.50		$5,850	$5,850
							Net Reduction in Cost=		$18,135
Option 2.2-21 - Re-use of Existing Telephone Sets From Mishawum Logan Express Station, Relocation and Re-Installation N.I.C. (Note: quantity and condition to be verified)									
2.2.14.28	(n.a.) closed circuit television cameras do not exist at Mishawum	0	ea						
2.2.14.28	(deduct) re-use existing telephone sets (verify availiable quantity/condition)	1	ea	$75.00		$75.00	$75.00		$75
							Net Reduction in Cost=		$75
Option 2.2-22 - Reduce Length of Building by 3'-2-1/2" (Reduce Sliding Doors Fromm 6' to 5' Wide, Vestibules From 12' to 10', Modify Mech Room & Stair/Elevator Layout)									
2.1.2.2	(add) 4"thick concrete sidewalks, with decorative finish (3.21'x49.33')	158	sf	$4.00		$4.00	$632		$632
2.2.1.1	(deduct) building excavation (5x2.5x2x3.21) from exist grade,incl backfill or disposal	3	cy	$4.50		$4.50	$14		$14
2.2.1.3	(deduct) furnish/place/compact/ struct fill on top of liner to underside slab (3.21x47.33x1.00)	6	cy	$20.00		$20.00	$120		$120
2.2.2.1	(deduct) exterior foundation and dado walls (1x3x2x3.21) and footings (3x1x2x3.21)	2	cy	$100.00	$180.00	$280.00	$200	$360	$560
2.2.2.6	(deduct) 6" slab on grade for ground floor, incl mesh reinforcing (3.21x47.33)	3	cy	$120.00	$135.00	$255.00	$360	$405	$765

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.2.7	(deduct) 4.25" elevated slab on metal deck for mezzanine, including reinforcing but not metal deck (0.3542)(47.33x3.21)	2	cy	$150.00	$270.00	$420.00	$300	$540	$840
2.2.3.1	(deduct) 8"insulated load bearing CMU-back-up on exterior wall(2x3.21x6.83)	44	sf	$3.00	$5.40	$8.40	$132	$238	$370
2.2.3.2	(deduct) 4" face brick-exterior wall (2x3.21x6.83)	44	sf	$5.00	$6.75	$11.75	$220	$297	$517
2.2.4.1	(deduct) structural steel framing for roof, mezzanine and columns	1	tn	$1,400.00	$675.00	$2,075.00	$1,400	$675	$2,075
2.2.4.2	(deduct) metal decking for mezzanine (1-1/2"composite, 20ga)	152	sf	$2.00	$1.80	$3.80	$304	$274	$578
2.2.4.3	(deduct) metal framing for roof (cold-rolled, 18 ga channel)	390	sf	$2.50	$1.80	$4.30	$975	$702	$1,677
2.2.4.4	(deduct) handrail-perimeter of mezzanine	7	lf	$56.00	$4.50	$60.50	$392	$32	$424
2.2.5.2	(deduct) 3/4" T&G plywood sheathing-roof deck	390	sf	$1.00	$0.68	$1.68	$390	$263	$653
2.2.5.3	(deduct) bead board-interior ceiling and exterior eaves	262	sf	$2.00	$1.35	$3.35	$524	$354	$878
2.2.6.2	(deduct) wall insulation-8" fiberglass on mezzanine level only	23	sf	$0.35	$0.36	$0.71	$8	$8	$16
2.2.6.3	(deduct) roof insulation-12"fiberglass	390	sf	$0.50	$0.36	$0.86	$195	$140	$335
2.2.6.4	(deduct) rigid insulation-1-1/2" (interior face foundation walls-2x3.21x2.5)	16	sf	$0.40	$0.68	$1.08	$6	$11	$17
2.2.6.5	(deduct) standing seam metal roof	343	sf	$3.50	$1.80	$5.30	$1,201	$617	$1,818
2.2.6.6	(deduct) asphalt shingles for roof	48	sf	$0.25	$1.35	$1.60	$12	$65	$77
2.2.6.7	(deduct) bit membrane under roof	390	sf	$0.35	$0.29	$0.64	$137	$114	$251
2.2.6.8	(deduct) metal gutter	7	lf	$2.00	$4.50	$6.50	$14	$32	$46
2.2.8.12	(deduct) painting-underside of mezzanine	152	sf	$0.12	$0.45	$0.57	$18	$68	$87
2.2.13.11	(deduct) sprinkler system, wet type, ordinary hazard (interior of Station Building only)	304	sf	$1.26	$1.17	$2.43	$383	$356	$739
							Net Reduction in Cost=		$12,222
Option 2.2-23 - Reduce Length of Building by One Bay-Lose 2 Tenant Spaces (Note: This option not accepted)									
2.1.2.2	(add) 4" thick concrete sidewalks, with decorative finish (14.00'x49.33')	691	sf	$4.00		$4.00	$2,764		$2,764
2.2.1.1	(deduct) building excavation (5x2.5x2x14) from exist grade,incl backfill or disposal	13	cy	$4.50		$4.50	$59		$59
2.2.1.3	(deduct) furnish/place/compact struct fill on top of liner to underside slab (14.00x47.33x1.00)	25	cy	$20.00		$20.00	$500		$500
2.2.2.1	(deduct) exterior foundation and dado walls (1x3x2x14) and footings (3x1x2x14)	6	cy	$100.00	$180.00	$280.00	$600	$1,080	$1,680
2.2.2.2	(deduct) exterior column footings and piers-2 total@(5x5x1.5+0.33x1.17x2.50)	3	cy	$120.00	$225.00	$345.00	$360	$675	$1,035
2.2.2.3	(deduct) interior column footings and piers-2 total@(3x3x1.25+1.17x1.17x1.00)	1	cy	$120.00	$225.00	$345.00	$120	$225	$345
2.2.2.4	(deduct) exterior pier for ornamental brackets-2 total@(1.83x1.33x3.00)	1	cy	$120.00	$225.00	$345.00	$120	$225	$345
2.2.2.6	(deduct) 6" slab on grade for ground floor, including mesh reinforcing (14.00x47.33)	4	cy	$120.00	$135.00	$225.00	$480	$540	$1,020
2.2.2.7	(deduct) 4.25" elevated slab on metal deck for mezzanine, including reinforcing but not metal deck (0.3542)(15.33x2x14.00)	6	cy	$150.00	$270.00	$420.00	$900	$1,620	$2,520
2.2.3.1	(deduct) 8" insulated load bearing CMU-back-up on exterior wall (2x14x6.83)	192	sf	$3.00	$5.40	$8.40	$576	$1,037	$1,613
2.2.3.2	(deduct) 4" face brick-exterior wall (2x14x6.83)	192	sf	$5.00	$6.75	$11.75	$960	$1,296	$2,256
2.2.4.1	(deduct) structural steel framing for roof, mezzanine and columns	4	tn	$1,400.00	$675.00	$2,075.00	$5,600	$2,700	$8,300
2.2.4.2	(deduct) metal decking for mezzanine (1-1/2" composite, 20ga)	406	sf	$2.00	$1.80	$3.80	$812	$731	$1,543
2.2.4.3	(deduct) metal framing for roof (cold-rolled, 18ga channel)	1,703	sf	$2.50	$1.80	$4.30	$4,258	$3,065	$7,323

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.4.4	(deduct) handrail-perimeter of mezzanine	28	lf	$56.00	$4.50	$60.50	$1,568	$126	$1,694
2.2.4.5	(deduct) ornamental ironwork-exterior brackets under eaves	2	ea	$1,200.00		$1,200.00	$2,400		$2,400
2.2.5.2	(deduct) 2/4" T&G plywood sheathing-roof deck	1,703	sf	$1.00	$0.68	$1.68	$1,703	$1,150	$2,853
2.2.5.3	(deduct) bear board-interior ceiling and exterior eaves	1,143	sf	$2.00	$1.35	$3.35	$2,286	$1,543	$3,829
2.2.6.2	(deduct) wall insulation-8" fiberglass on mezzanine level only	98	sf	$0.35	$0.36	$0.71	$34	$35	$70
2.2.6.3	(deduct) roof insulation-12" fiberglass	1,703	sf	$0.50	$0.36	$0.86	$852	$613	$1,465
2.2.6.4	(deduct) rigid insulation-1-1/2" (interior face foundation walls-2x14x2.5)	70	sf	$0.40	$0.68	$1.08	$28	$47	$75
2.2.6.5	(deduct) standing seam metal roof	1,494	sf	$3.50	$1.80	$5.30	$5,229	$2,689	$7,918
2.2.6.6.	(deduct) asphalt shingles for roof	209	sf	$0.25	$1.35	$1.60	$52	$282	$334
2.2.6.7	(deduct) bit membrane under roof	1,703	sf	$0.35	$0.29	$0.64	$596	$498	$1,094
2.2.6.8	(deduct) metal gutter	28	lf	$2.00	$4.50	$6.50	$56	$126	$182
2.2.7.1	(deduct) 3'-0" hollow mwtal door, including hardware	2	ea	$750.00	$180.00	$930.00	$1,500	$360	$1,860
2.2.7.4	(deduct) 7'hx12'w roll-up grilles (manual operation)	2	ea	$2,500.00	$360.00	$2,860.00	$5,000	$720	$5,720
2.2.7.6	(deduct) 4'x4' custom wood window/awning	6	ea	$640.00	$90.00	$730.00	$3,840	$540	$4,380
2.2.8.12	(deduct) painting-underside of mezzanine	406	sf	$0.12	$0.45	$0.57	$49	$183	$231
2.2.13.11	(deduct) sprinkler system, wet type, ordinary hazard(interior of Station Building only)	784	sf	$1.26	$1.17	$2.43	$988	$917	$1,905
2.2.14.4	(deduct) tenant panelboard transformer and meters (2)	1	ls	$2,000.00		$2,000.00	$2,000		$2,000
2.2.14.5	(deduct) tenant panelboard	1	ls	$2,000.00		$2,000.00	$2,000		$2,000
2.2.14.13	(deduct) electric service for tenant roll-up grille-RG 3C, GR 4D	1	ls	$1,000.00		$1,000.00	$1,000		$1,000
2.2.14.22	(deduct) perforated pendant flourescent light on mezzanine	1	ea	$150.00	$96.00	$246.00	$150	$96	$246
2.2.14.23	(deduct) surface mounted ceiling fixtures under eaves	2	ea	$120.00	$58.50	$178.50	$240	$117	$357
2.2.14.24	(deduct) wall scones in lobby	2	ea	$85.00	$33.75	$118.75	$170	$68	$238
							Net Reduction in Cost=		$67,625
TOTAL OF OPTIONS FOR SITEWORK COST REDUCTIONS							Total Net Reduction in Cost for Station Building Options (6,7,9,10,11,12,14,16,17,18,23 not incl.)=		$184,244
							Building Costs at 30% Estimate=		$1,451,867
							Station Building Costs With Options Accepted 8-12-98=		$1,267,623
							TOTAL NET REDUCTION FOR SITESIDE COSTS, INCLUDING SITEWORK AND STATION BUILDING REDUCTIONS=		$736,751
							Sitework and Station Building Costs at 30% Estimate=		$5,117,103
							Sitework and Station Building Costs if All Options Selected=		$4,380,352

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Aug 1998)

Appendix E

FINAL DESIGN - 60% SUBMITTAL
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2	SITE SIDE CONSTRUCTION								
2.1	SITEWORK								
2.1.1	EARTHWORK								
2.1.1.1	field office (1)-shared by MPA&MBTA Res.Eng's	12	mon	$1,200.00		$1,200.00	$14,400		$14,400
2.1.1.2	sheetpiling around deep excavation for tie-in to existing 20" water main (assume 10'x10'x20' sheeting; install and remove when no longer required)	800	sf	$24.00		$24.00	$19,200		$19,200
2.1.1.3	dewatering of deep excavation for tie-in to existing 20" main (approved method for disposal of contaminated groundwater is required)	1	ls	$10,000.00		$10,000.00	$10,000		$10,000
2.1.1.4	excavation and backfill of contaminated soils in deep excavation for tie-in to existing 20" water main (assume 10'x10'x15' deep excavation)	55	cy	$20.00		$20.00	$1,100		$1,100
2.1.1.5	excavation	2,200	cy	$6.90	$3.45	$10.35	$15,180	$7,590	$22,770
2.1.1.6	fine grading	102,500	sy	$0.00	$1.12	$1.12		$114,800	$114,800
2.1.1.7	soil loam	160	cy	$2.85		$2.85	$456		$456
2.1.1.8	seed	180,000	sf	$0.25		$0.25	$45,000		$45,000
2.1.1.9	gravel borrow for filling to subgrade (including 25% for compaction as per MHD guidelines	21,000	cy	$5.30	$3.31	$8.61	$111,300	$69,505	$180,805
2.1.1.10	ordinary burrow	23,710	cy	$3.66	$2.50	$6.16	$86,779	$59,275	$146,054
2.1.1.11	class B trench excavation	5,185	cy	$0.00	$5.50	$5.50		$28,517	$28,517
2.1.1.12	class B rock excavation	25	cy	$0.00	$58.00	$58.00		$1,450	$1,450
2.1.1.13	rip-rap for slope protection	1,000	cy	$20.00	$10.00	$30.00	$20,000	$10,000	$30,000
2.1.1.14	hay bales	2,330	lf	$1.54	$0.77	$2.31	$3,588	$1,794	$5,382
2.1.1.15	siltation fence	2,330	lf	$2.48	$1.24	$3.72	$5,778	$2,889	$8,668
2.1.1.16	roadway excavation (Atlantic Ave)	225	cy	$27.00		$27.00	$6,075		$6,075
2.1.1.17	bituminous sawcutting (Atlantic Ave)	1,000	lf	$2.00		$2.00	$2,000		$2,000
2.1.1.18	pavement milling (Atlantic Ave)	1,550	sy	$4.40	$4.58	$8.98	$6,820	$7,099	$13,919
	SUBTOTAL: EARTHWORK						$347,676	$302,918	$650,594

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.2	SIDEWALKS, CURBING, PAVING, AND STRIPING								
2.1.2.1	4" thick concrete sidewalks	5,550	sy	$11.88	$5.94	$17.82	$65,934	$32,967	$98,901
2.1.2.2	6" thick portland cement concrete pavement at busway	417	cy	$90.00		$90.00	$37,530		$37,530
2.1.2.3	bollards	24	ea	$400.00	$100.00	$500.00	$9,600	$2,400	$12,000
2.1.2.4	Class I bituminus concrete pavament -(base course, 3" at heavy duty sections)	13,900	tn	$26.00	$7.50	$33.50	$361,400	$104.25	$465,650
2.1.2.5	Class I bituminus concrete pavament - (top course 1-1/2"+binder course 2-1/2" or 1-1/2" at HD)	9,300	tn	$26.00	$7.50	$33.50	$241,800	$69,750	$311,550
2.1.2.6	tack coat	5,000	gal	$0.90	$0.70	$1.60	$4,500	$3,500	$8,000
2.1.2.7	prime coat	5,000	gal	$0.90	$0.70	$1.60	$4,500	$3,500	$8,000
2.1.2.8	vertical granite curbing, type vb - straight	3,200	lf	$9.09	$7.00	$16.09	$29,088	$22,400	$51,488
2.1.2.9	vertical granite curbing, type vb - curved	1,300	lf	$15.39	$7.00	$22.39	$20,007	$9,100	$29,107
2.1.2.10	granite transition for wheelchair ramp-straight	125	lf	$59.34	$19.75	$79.09	$7,418	$2,469	$9,886
2.1.2.11	granite transition for wheelchair ramp-curved	25	lf	$79.34	$19.75	$99.09	$1,984	$494	$2,477
2.1.2.12	granite curb, type sb-straight	7,800	lf	$5.00	$6.00	$11.00	$39,000	$46,800	$85,800
2.1.2.13	granite curb, type sb-curved	120	lf	$5.00	$6.00	$11.00	$600	$720	$1,320
2.1.2.14	granite curb inlet - straight	11	ea	$153.00	$212.00	$365.00	$1,683	$2,332	$4,015
2.1.2.15	granite curb inlet - curved	3	ea	$220.00	$212.00	$432.00	$660	$636	$1,296
2.1.2.16	pavement legents	62,000	lf	$0.06	$0.18	$0.24	$3,720	$11,160	$14,880
2.1.2.17	4" reflectorized white line	825	lf	$0.20	$0.34	$0.54	$165	$280	$445
2.1.2.18	4" reflectorized yellow line	32	ea	$10.00	$30.00	$40.00	$320	$960	$1,280
2.1.2.19	12" reflectorized white line	100	lf	$2.38		$2.38	$238		$238
2.1.2.20	12" reflectorized yelloww line	500	lf	$2.38		$2.38	$1,190		$1,190
2.1.2.21	handicapped striping and symbols	32	ea	$40.00		$40.00	$1,280		$1,280
	SUBTOTAL: SIDEWALK, CURB, PAVING, STRIPING						$832,616	$313,317	$1,146,333
2.1.3	UTILITIES								
2.1.3.1	4" cament-lined ductile iron water pipe for connecton to building	20	lf	$12.00	$14.00	$26.00	$240	$280	$520
2.1.3.2	4" gate valve and box	1	ea	$300.00	$149.99	$449.99	$300	$150	$450
2.1.3.3	6" cement-lined ductile iron water pipe for fire service	1,750	lf	$24.00	$18.00	$42.00	$42,000	$31,500	$73,500
2.1.3.4	6" gate valve and box	7	ea	$400.00	$200.00	$600.00	$2,800	$1,400	$4,200
2.1.3.5	fire hydrant	7	ea	$1,100.00	$500.00	$1,600.00	$7,700	$3,500	$11,200
2.1.3.6	installation of 20" cement-lined ductile iron water pipe (material furnished by City of Woburn)	1,550	lf		$30.00	$30.00		$46,502	$46,502
2.1.3.7	20" gate valve and box	2	ea		$800.01	$800.01		$1,600	$1,600
2.1.3.8	gate box adjusted	2	ea		$204.98	$204.98		$410	$410
2.1.3.9	connect to existing 20" City water main (20" gate valves and boxes to be furnished by City, installed by this contract)	2	ea	$1,000.00	$1,499.99	$2,499.99	$2,000	$3,000	$5,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.3.10	6" PVC pipe for sanitary sewer service from building	220	lf	$5.00	$17.00	$22.00	$1,100	$3,740	$4,840
2.1.3.11	connect to existing sanitary sewer system	1	ea	$200.00	$799.97	$999.97	$200	$800	$1,000
2.1.3.12	sanitary structure adjusted	1	ea	$37.00	$147.00	$184.00	$37	$147	$184
2.1.3.13	allowance to cover installation of new gas line from Atlantic Avenue to Station Building (by Boston Gas Co. or sitework contractor)	1,300	lf	$15.00		$15.00	$19,500		$19,500
2.1.3.14	allowance to cover connection of new gas line into existing gas main in Atlantic Avenue (by Boston Gas. Co. or sitework contractor)	1	ea	$2,000.00	$900.00	$2,900.00	$2,000	$900	$2,900
2.1.3.15	sanitary sewer manholes	3	ea	$739.00	$1,725.00	$2,464.00	$2,217	$5,175	$7,392
	SUBTOTAL: UTILITIES						$80,094	$99,104	$179,198
2.1.4	STORM DRAINAGE								
2.1.4.1	12" dia polyethylene pipe for storm drain	225	lf	$6.00	$10.00	$16.00	$1,350	$2,250	$3,600
2.1.4.2	12" dia RCP pipe for storm drain	30	lf	$10.00	$14.00	$24.00	$300	$420	$720
2.1.4.3	manhole	1	ea	$700.00	$2,100.02	$2,800.02	$700	$2,100	$2,800
2.1.4.4	catch basin	7	ea	$700.00	$2,100.02	$2,800.02	$4,900	$14,700	$19,600
2.1.4.5	drainage structure adjusted	5	ea	$165.00	$175.01	$340.01	$825	$875	$1,700
2.1.4.6	drainage structure change in type	5	ea	$583.00	$520.97	$1,103.97	$2,915	$2,605	$5,520
2.1.4.7	drainage structure remodeled	8	ea	$298.00	$207.99	$505.99	$2,384	$1,664	$4,048
2.1.4.8	frame and cover	9	ea	$185.00	$99.99	$284.99	$1,665	$900	$2,565
2.1.4.9	frame and grate	26	ea	$185.00	$99.99	$284.99	$4,810	$2,600	$7,410
2.1.4.10	frame and grate-remove and stack	2	ea		$45.00	$45.00		$90	$90
2.1.4.11	masonry plug	10	sf	$1.67	$40.10	$41.77	$17	$401	$418
	SUBTOTAL: STORM DRAINAGE						$19,866	$28,604	$48,470
2.1.5	FENCING, GUARDRAIL, SIGNAGE								
2.1.5.1	8' high vinyl coated chain link fence (around 3 sides of long-term parking only)	1,600	lf	$9.00	$9.00	$18.00	$14,400	$14,400	$28,800
2.1.5.2	4' high vinyl coated chain link fence	1,250	lf	$7.00	$7.00	$14.00	$8,750	$8,750	$17,500
2.1.5.3	12' wide gate in 6' high chain link fence	3	ea	$338.00	$432.00	$770.00	$1,014	$1,296	$2,310
2.1.5.4	chain link fence-remove and stack	525	lf		$13.83	$13.83		$7,260	$7,260
2.1.5.5	chain link fence gate-remove and stack	22	lf		$18.20	$18.20		$400	$400
2.1.5.6	6' high steel ornamental fence (along access road of long term parking)	850	lf	$80.00		$80.00	$68,000		$68,000
2.1.5.7	steel guardrail and posts, highway type	3,200	lf	$9.45	$1.36	$10.81	$30,240	$4,352	$34,592
2.1.5.8	steel guardrail and posts, highway type-curved	250	lf	$9.45	$1.36	$11	$2,363	$340	$2,702
2.1.5.9	steel guardrail terminal section	5	ea	$41.50	$4.50	$46	$208	$23	$230

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.5.10	signs with sign posts, for directional signage	225	sf	$5.10	$5.07	$10.17	$1,148	$1,141	$2,288
2.1.5.11	station signage	1	ea	$10,000.00		$10,000.00	$10,000		$10,000
	SUBTOTAL: FENCING, GUARDRAIL, SIGNAGE						$136,122	$37,961	$174,082
2.1.6	PLANTING								
2.1.6.1	loam (2' deep in planting areas, 6" deep in grass areas)	2,100	cy	$25.00		$25.00	$52,500		$52,500
2.1.6.2	trees in allees (3" to 3.5" caliper, staked and guyed)	71	ea	$800.00		$800.00	$56,800		$56,800
2.1.6.3	tree underdrainage test pits	10	ea	$100.00		$100.00	$1,000		$1,000
2.1.6.4	seed (in tree islands only)	51,330	sf	$0.25		$0.25	$12,833		$12,833
2.1.6.5	plant maintenance (1 year)	1	ls	$3,000.00		$3,000.00	$3,000		$3,000
	SUBTOTAL: PLANTING						$126,133		$126,133
2.1.7	SITE ACCESSORIES								
2.1.7.1	irrigation system	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
2.1.7.2	bicycle rack, loop style	8	ea	$250.00		$250.00	$2,000		$2,000
2.1.7.3	8' long free-standing metal bench	6	ea	$1,880.00	$404.00	$2,284.00	$11,280	$2,424	$13,704
2.1.7.4	6' long free-standing metal bench	6	ea	$1,700.00	$245.00	$1,945.00	$15,300	$2,205	$17,505
2.1.7.5	site trash receptacles	7	ea	$1,600.00	$52.00	$1,652.00	$11,200	$364	$11,564
2.1.7.99	SUBTOTAL: SITE ACCESSORIES						$59,780	$4,993	$64,773
2.1.8	SITE ELECTRICAL								
2.1.8.1	normal power-secondary transformer cables (2-1/c#350mcp/ph w/neut & grd#2awg, rated 600v) underground from transformer to station building electric room (13'coil+85u.g.+12'coil=110'/cablex10cables=1100')	1,100	lf	$11.00	$3.15	$14.15	$12,100	$3,465	$15,565
2.1.8.2	normal power-terminations	1	ls	$6,450.00		$6,450.00	$6,450		$6,450
2.1.8.3	cast in place concrete	785	cy	$70.00	$20.00	$90.00	$54,950	$15,700	$70,650
2.1.8.4	3/4" PVC conduit	13,000	lf	$0.27	$0.85	$1.12	$3,510	$11,050	$14,560
2.1.8.5	underground conduit-2"PVC, schedule 80, direct buried (for site lighting, security/communications)	11,450	lf	$3.20		$3.20	$36,640		$36,640
2.1.8.6	underground conduit-3"PVC, schedule 80, direct buried	500	lf	$1.65	$2.05	$3.70	$825	$1,025	$1,850
2.1.8.7	underground conduit-4"PVC, schedule 40, to be conc encased, conc not included (4 conduit duct bank, 1215' long, Atlantic Ave to Sta bldg-power tel/comm, plus 2 spares)	5,000	lf	$4.00		$4.00	$20,000		$20,000
2.1.8.8	underground conduit-5" PVC, schedule 80, direct buried	2,600	lf	$3.70	$4.10	$7.80	$9,620	$10,660	$20,280
2.1.8.9	ground rod with clamp	29	ea	$127.06	$0.25	$127.31	$3,685	$7	$3,692
2.1.8.10	#6 AWG Cu wire	46,000	lf	$0.28	$0.38	$0.66	$12,880	$17,479	$30,359
2.1.8.11	#10 AWG Cu wire	17,100	lf	$0.10	$0.25	$0.35	$1,710	$4,271	$5,981
2.1.8.12	pull rope	32,550	lf	$0.14		$0.14	$4,557		$4,557

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.8.13	precast manhole (4'x6'x6")	2	ea	$1,600.00	$630.00	$2,230.00	$3,200	$1,260	$4,460
2.1.8.14	handhole cover and frame	27	ea	$450.00		$450.00	$12,150		$12,150
2.1.8.15	precast manhole (4'x4'x4')	3	ea	$1,100.00	$435.00	$1,535.00	$3,300	$1,305	$4,605
2.1.8.16	precast manhole (24"x24"x36")	24	ea	$330.00	$254.00	$584.00	$7,920	$6,096	$14,016
2.1.8.17	40' pole installed on roadway (G-1)	17	ea	$1,627.06		$1,627.06	$27,660		$27,660
2.1.8.18	foundation for 40' pole	17	ea	$650.00		$650.00	$11,050		$11,050
2.1.8.19	1-250w luminar installed on 40' pole	17	ea	$586.28		$586.28	$9,967		$9,967
2.1.8.20	50' pole installed in parking lot (G-2A)	13	ea	$2,177.06		$2,177.06	$28,302		$28,302
2.1.8.21	foundation for 50' pole	13	ea	$750.00		$750.00	$9,750		$9,750
2.1.8.22	2-250w/2-400w luminar installed on 50' pole	13	ea	$2,372.12		$2,372.12	$30,838		$30,838
2.1.8.23	50' pole installed in parking lot (G-2B)	10	ea	$2,177.06		$2,177.06	$21,771		$21,771
2.1.8.24	foundation for 50' pole	10	ea	$750.00		$750.00	$7,500		$7,500
2.1.8.25	2-250w/2-400w luminar installed on 50' pole	10	ea	$2,372.12		$2,372.12	$23,721		$23,721
2.1.8.26	25' pole w/4.4 mast arm installed (G-3)	36	ea	$1,052.06		$1,052.06	$37,874		$37,874
2.1.8.27	foundation for 25' pole	36	ea	$600.00		$600.00	$21,600		$21,600
2.1.8.28	1-250w luminar installed on 25' pole	36	ea	$561.28		$561.28	$20,206		$20,206
2.1.8.29	40' pole installed on roadway (G-4)	5	ea	$1,327.06		$1,327.06	$6,635		$6,635
2.1.8.30	foundation for 40' pole	5	ea	$650.00		$650.00	$3,250		$3,250
2.1.8.31	2-250w luminar installed on 40' pole	5	ea	$1,172.56		$1,172.56	$5,863		$5,863
2.1.8.32	14' decorative pole, pedestrian lighting (G-5)	10	ea	$927.06		$927.06	$9,271		$9,271
2.1.8.33	foundation for 14' pole	10	ea	$400.00		$400.00	$4,000		$4,000
2.1.8.34	1-175w luminar installed on 14' pole	10	ea	$875.00		$875.00	$8,750		$8,750
2.1.8.35	communications system for site (telephone, public address, etc.)	1	ls	$17,685.00		$17,685.00	$17,685		$17,685
	SUBTOTAL: SITE ELECTRICAL						$499,189	$72,318	$571,506
2.1.10	MISCELLANEOUS SITE STRUCTURES								
2.1.10.1	Site canopies at bus platforms-(2) 14-10"x98'-8" half-canopies at Logan Express and local bus berths (assume galvanized steel, similar to MBTA standard half-canopies, including foundations, lighting)	2,927	sf	$35.00		$35.00	$102,445		$102,445
2.1.10.2	Site canopies at park-and-ride platforms-(1)12'-10"x50-8"half-canopies at van loading areas (assume galvanized steel, similar to MBTA half-canopies, including foundations and lighting)	650	sf	$35.00		$35.00	$22,750		$22,750
2.1.10.3	Pay box canopies (3)-8'-0"x3'-0"	72	sf	$35.00		$35.00	$2,520		$2,520
2.1.10.4	Sign tower structure at Atlantic Avenue entrance-assume steel framed, with logo signs for 3 agencies, including foundations and lighting	1	ea	$18,000.00		$18,000.00	$18,000		$18,000

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.1.10.5	Site Maintenance Storage Building-12'x14'-8" pre-fabricated steel with metal panels, mounted on slab-on-grade, electric and lights)	1	ea	$17,600.00		$17,600.00	$17,600		$17,600
2.1.10.6	exterior transformer pads, condenser foundations, dumpster pad	7	cy	$75.90	$32.86	$108.76	$531	$230	$761
2.1.10.7	6" high chain link fence with screen	135	lf	$20.00		$20.00	$2,700		$2,700
2.1.10.8	6' high chain link fence gates	18	lf	$20.00		$20.00	$360		$360
	SUBTOTAL: MISCELLANEOUS SITE STRUCTURES						$166,906	$230	$167,136
2.1.11	SITESIDE ENVIRONMENTAL SERVICES								
2.1.11.1	Licenced Site Professional on-site during critical earthwork operations	1	ls		$20,000.00	$20,000.00		$20,000	$20,000
2.1.11.2	laboratory testing services	1	ls		$5,000.00	$5,000.00		$5,000	$5,000
	SUBTOTAL: SITESIDE ENVIRONMENTAL SERVICES							$25,000	$25,000
						SUBTOTAL: SITEWORK NOT INCLUDING AFI	$2,268,381	$884,845	$3,153,226
							$113,419	$44,242	$157,661
						SUBTOTAL: SITEWORK INCLUDING AFI	$2,381,800	$929,088	$3,310,887

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Oct. 1998)

FINAL DESIGN - 60% SUBMITTAL
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2	STATION BUILDING - SCHEME 1 (RECTANGULAR, 113'-4"X49'-4") + TOWER								
2.2.1	EARTHWORK								
2.2.1.1	building excavation	155	cy			$7.94		$1,228	$1,228
2.2.1.2	structural fill under concrete slab	212	cy	$17.00		$10.96	$3,596	$2,319	$5,915
	SUBTOTAL: EARTHWORK						$3,596	$3,547	$7,144
2.2.2	CONCRETE								
2.2.2.1	concrete footing formwork	822	sf	$1.51	$5.48	$6.98	$1,238	$4,501	$5,739
2.2.2.2	concrete footing formwork-interior columns	245	sf	$1.15	$5.48	$6.63	$282	$1,342	$1,624
2.2.2.3	concrete frost wall formwork	1,975	sf	$1.27	$6.02	$7.29	$2,499	$11,901	$14,400
2.2.2.4	pilaster @ frost wall formwork	302	sf	$1.90	$16.43	$18.33	$573	$4,963	$5,536
2.2.2.5	footing rebar	84	cwt	$32.20	$60.24	$92.44	$2,698	$5,047	$7,744
2.2.2.6	wall rebar	54	cwt	$32.20	$60.24	$92.44	$1,752	$3,278	$5,031
2.2.2.7	interior column dowels	2	cwt	$32.20	$82.15	$114.35	$66	$168	$234
2.2.2.8	welded wire fabric for slab on grade and mezzanine	8,202	sf	$0.35	$0.33	$0.68	$2,871	$2,695	$5,566
2.2.2.9	sawcut SOG	581	lf	$0.75	$1.10	$1.84	$434	$636	$1,071
2.2.2.10	concrete-footing	53	cy	$75.90	$54.77	$130.67	$4,043	$2,917	$6,961
2.2.2.11	concrete footing-interior columns	16	cy	$75.90	$54.77	$130.67	$1,232	$889	$2,122
2.2.2.12	concrete-frost wall	35	cy	$75.90	$32.86	$108.76	$2,679	$1,160	$3,838
2.2.2.13	concrete-pilaster @ frost wall	5	cy	$75.90	$65.72	$141.62	$410	$355	$764
2.2.2.14	concrete - stairs	0.4	cy	$75.90	$109.53	$185.43	$33	$48	$81
2.2.2.15	concrete - 6" slab on grade	118	cy	$75.90	$27.38	$103.28	$8,955	$3,231	$12,186
2.2.2.16	concrete - floor deck, 4-1/2"	42	cy	$75.90	$27.38	$103.28	$3,222	$1,162	$4,384
2.2.2.17	finishing 6" slab on grade and mezzanine	8,202	sf	$0.12	$0.82	$0.94	$943	$6,738	$7,681
	SUBTOTAL: CONCRETE						$33,930	$51,032	$84,962
2.2.3	MASONRY								
2.2.3.1	4" face brick-exterior wall	2,733	sf	$3.10	$8.91	$12.01	$8,471	$24,361	$32,831
2.2.3.2	brick for soldier course	666	sf	$3.10	$10.25	$13.35	$2,066	$6,827	$8,893
2.2.3.3	brick for stepped course at middle of columns	28	sf	$3.10	$10.25	$13.35	$85	$282	$367
2.2.3.4	rounded brick at bottom of columns	52	sf	$5.47	$10.25	$15.72	$285	$534	$819
2.2.3.5	brick for sailor course	62	sf	$2.05	$8.68	$10.73	$127	$538	$665
2.2.3.6	brick for edged course	241	sf	$3.10	$14.47	$17.57	$748	$3,941	$4,239

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.3.7	brick sill rowlock course	150	sf	$5.47	$20.49	$25.96	$818	$3,066	$3,885
2.2.3.8	8" insulated load bearing CMU, with styrafoam insert	5,024	sf	$2.90	$5.62	$8.52	$14,570	$28,211	$42,781
2.2.3.9	8" bond beam, including grout and rebar	565	lf	$3.05	$4.46	$7.51	$1,722	$2,517	$4,240
2.2.3.10	vertical rebar, 8' high including grout, 4' oc	1,355	lf	$0.70	$2.89	$3.59	$948	$3,921	$4,869
	SUBTOTAL: MASONRY						$29,841	$73,749	$103,590
2.2.4	STRUCTURAL STEEL								
2.2.4.1	steel columns	11	ton	$1,450.00	$782.33	$2,232.33	$16,004	$8,635	$24,639
2.2.4.2	steel framing for mezzanine	17	ton	$1,450.00	$782.33	$2,232.33	$24,185	$13,049	$37,233
2.2.4.3	eave roof framing	6	ton	$1,450.00	$782.33	$2,232.33	$9,399	$5,071	$14,469
2.2.4.4	steel roof framing	18	ton	$1,450.00	$782.33	$2,232.33	$26,824	$14,472	$41,296
2.2.4.5	mezz roof diagonal bracking W4x13	0.4	ton	$1,450.00	$1,173.49	$2,623.49	$528	$427	$955
2.2.4.6	metal floor deck, 1-1/2"' deep, 20 gauge	2,729	sf	$1.15	$0.78	$1.93	$3,138	$2,135	$5,273
2.2.4.7	soffit framing 6SW18	1,570	lf	$1.45	$1.41	$2.86	$2,274	$2,210	$4,484
2.2.4.8	roof framing 8SW16	3,864	lf	$1.79	$1.96	$3.75	$6,932	$7,557	$14,489
2.2.4.9	roof framing 8SW18	2,049	lf	$1.56	$1.64	$3.21	$3,205	$3,367	$6,572
2.2.4.10	plates/ties/anchors/connections on structural steel	1	ls	$14,941.00		$14,941.00	$14,941		$14,941
	SUBTOTAL: STRUCTURAL STEEL						$107,430	$56,923	$164,352
2.2.5	MISC STEEL								
2.2.5.1	steel channel for stairs	1,325	lb	$1.04	$0.78	$1.82	$1,371	$1,036	$2,408
2.2.5.2	steel pan stair frame for stairs	111	sf	$23.00	$3.91	$26.91	$2,547	$433	$2,980
2.2.5.3	black steel handrail	232	lf	$35.00	$23.47	$58.47	$8,120	$5,445	$13,565
2.2.5.4	black steel spindle for railing	100	ea	$28.75	$7.82	$36.57	$2,875	$782	$3,657
2.2.5.5	lintle angles, brick shelves and misc. framing	1	ls	$18,000.00		$18,000.00	$18,000		$18,000
2.2.5.6	ornamental brackets	20	ea	$950.00	$312.93	$1,262.93	$18,050	$5,946	$23,996
	SUBTOTAL: MISC STEEL						$50,963	$13,643	$64,605
2.2.6	WOODS AND PLASTICS								
2.2.6.1	base cabinets in ticketing area	33	lf	$230.00	$20.08	$250.08	$7,590	$663	$8,253
2.2.6.2	countertop for ticketing area	33	lf	$69.00	$13.39	$82.39	$2,277	$442	$2,719
2.2.6.3	wood grille for clock tower	132	sf	$17.25	$11.73	$28.98	$2,277	$1,549	$3,826
2.2.6.4	3/4" tongue an dgroove plywood sheathing	12,612	sf	$0.75	$0.87	$1.62	$9,427	$10,976	$20,403
2.2.6.5	1/2" CDX plywood sheathing	3,726	sf	$0.58	$0.47	$1.04	$2,142	$1,746	$3,889
2.2.6.6	trim for metal doors	686	lf	$0.92	$1.57	$2.49	$631	$1,079	$1,710
2.2.6.7	trim for wood windows	3,022	lf	$0.92	$1.57	$2.49	$2,781	$4,752	$7,533
2.2.6.8	8" crown trim around roof	843	lf	$2.40	$2.10	$4.50	$2,023	$1,767	$3,790
2.2.6.9	8" crown trim for roof	50	lf	$2.40	$2.62	$5.02	$120	$131	$251
2.2.6.10	2-1/2" crown trim for underside of overhang	586	lf	$1.20	$1.57	$2.77	$703	$921	$1,625

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.6.11	1/4" round trim at the brackets	1,050	lf	$0.60	$1.57	$2.17	$630	$1,651	$2,281
2.2.6.12	1x3 at edge of beadboard	1,504	lf	$0.90	$1.57	$2.47	$1,354	$2,365	$3,718
2.2.6.13	interior window sills & aprons	1,234	lf	$1.38	$3.14	$4.52	$1,703	$3,881	$5,584
2.2.6.14	exterior window sills	673	sf	$1.73	$2.62	$4.35	$1,161	$1,763	$2,924
2.2.6.15	bleached white cedar shiplap siding	703	sf	$3.45	$5.24	$8.69	$2,425	$3,684	$6,110
2.2.6.16	beadboard for interior walls	783	sf	$4.00	$3.98	$7.98	$3,132	$3,119	$6,251
2.2.6.17	beadboard for overhang and ceilings	13,865	sf	$1.94	$1.57	$3.52	$26,946	$21,798	$48,744
	SUBTOTAL: WOODS AND PLASTICS						$67,322	$62,285	$129,607
2.2.7	THERMAL AND MOISTURE PROTECTION								
2.2.7.1	bituthane membrane under asphalt shingles	11,684	sf	$0.69	$0.19	$0.88	$8,062	$2,229	$10,290
2.2.7.2	asphalt damproofing for brick work	3,626	sf	$0.16	$0.93	$1.09	$584	$3,359	$3,943
2.2.7.3	9" fiberglass wall insulation R-30	140	sf	$0.63	$0.37	$1.00	$89	$51	$140
2.2.7.4	3 1/2" fiberglass roof insulation R-11	500	sf	$0.21	$0.37	$0.57	$104	$183	$287
2.2.7.5	12" fiberglass roof insulation R-38	3,356	sf	$0.74	$0.42	$1.16	$6,886	$3,922	$10,808
2.2.7.6	1-1/2" rigid insulation around foundation walls	790	sf	$0.40	$0.63	$1.03	$316	$497	$813
2.2.7.7	asphalt shingles for roof-235lb GAF	11,684	sf	$0.48	$0.84	$1.32	$5,608	$9,797	$15,405
2.2.7.8	metal siding for walkway to bridge 20 GA	117	sf	$3.09	$4.40	$7.50	$362	$515	$877
2.2.7.9	copper flashing for roof 16 oz	678	sf	$3.85	$3.67	$7.52	$2,612	$2,487	$5,099
2.2.7.10	copper leaders, rectangular 3"x4"	250	lf	$6.10	$2.88	$8.98	$1,525	$721	$2,246
2.2.7.11	lead coated copper flashing for clock tower 5 oz	153	sf	$1.61	$1.26	$2.87	$246	$192	$439
2.2.7.12	APDM lined hidden gutters	408	sf	$1.73	$7.86	$9.59	$704	$3,207	$3,911
2.2.7.13	caulking and sealant-allowance	1	ls	$8,000.00		$8,000.00	$8,000		$8,000
	SUBTOTAL: THERMAL AND MOISTURE PROTECTION						$35,096	$27,161	$62,257
2.2.8	DOORS AND WINDOWS								
2.2.8.1	3' hollow metal door, single, including hardware	20	ea	$460.00	$209.63	$669.63	$9,200	$4,193	$13,393
2.2.8.2	1.5' hollow metal door, double, including hardware	1	ea	$402.50	$209.63	$612.13	$403	$210	$612
2.2.8.3	3' hollow metal door, double, including hardware	3	ea	$862.50	$419.26	$1,281.76	$2,588	$1,258	$3,845
2.2.8.4	3'-6" hollow metal door, single, with transom including hardware	1	ea	$1,200.00	$419.26	$1,619.26	$1,200	$419	$1,619
2.2.8.5	6' automatic sliding glass door	2	ea	$10,580.00	$1,048.14	$11,628.14	$21,160	$2,096	$23,256
2.2.8.6	3.75'x4' bullet proof glass for ticket and seating area	17	sf	$29.90	$5.24	$35.14	$508	$89	$597
2.2.8.7	2.5' high bullet proof glass for ticket windows	34	sf	$29.90	$5.24	$35.14	$1,017	$178	$1,195
2.2.8.8	7'hx12'w roll up grilles (manually operated)	4	ea	$2,070.00	$419.26	$2,489.26	$8,280	$1,677	$9,957
2.2.8.9	2'x4' wood windows for interior of building	18	ea	$300.00	$52.41	$352.41	$5,400	$943	$6,343
2.2.8.10	3'-10"x2'-8" vinyl wood clad windows with awnings	6	ea	$320.00	$52.41	$372.41	$1,920	$314	$2,234
2.2.8.11	6'-0"x2'-8" vinyl wood clad windows with awnings	2	ea	$550.00	$104.81	$654.81	$1,100	$210	$1,310
2.2.8.12	2'-8"x2'-8" vinyl wood clad windows with awnings	4	ea	$250.00	$52.41	$302.41	$1,000	$210	$1,210

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.8.13	3'-8"x2'-8" vinyl wood clad windows with awnings	2	ea	$320.00	$52.41	$372.41	$640	$105	$745
2.2.8.14	4'-0"x4'-0" vinyl wood clad windows with awnings	28	ea	$400.00	$78.61	$478.61	$11,200	$2.20	$13,401
2.2.8.15	8'-7"x4'-0" vinyl wood clad windows with awnings	1	ea	$1,380.00	$209.63	$1,589.63	$1,380	$210	$1,590
2.2.8.16	9'-10"x3'-5" semiricle vinyl wood clad window	1	ea	$2,875.00	$838.51	$3,713.51	$2,875	$839	$3,714
2.2.8.17	2'x2' spandrel glass with metal frame	4	ea	$175.00	$52.41	$227.41	$700	$210	$910
2.2.8.18	4'x5' triangular windows	4	ea	$630.00	$209.63	$839.63	$2,520	$839	$3,359
2.2.8.19	2.5'x3.5' triangular windows	4	ea	$460.00	$209.63	$669.63	$1,840	$839	$2,679
2.2.8.20	1.5'x4' triangular windows	4	ea	$345.00	$157.22	$502.22	$1,380	$629	$2,009
2.2.8.21	4'-0"x2'-8" vinyl wood clad windows with awnings	39	ea	$320.00	$52.41	$372.41	$12,480	$2,044	$14,524
2.2.8.22	5'-6"x2'-8" vinyl wood clad windows with awnings	3	ea	$550.00	$78.61	$628.61	$1,650	$236	$1,886
2.2.8.23	2'-9"x4'-0" vinyl wood clad windows with awnings	2	ea	$320.00	$52.41	$372.41	$640	$105	$745
	SUBTOTAL: DOORS AND WINDOWS						$91,080	$20,051	$111,131
2.2.9	FINISHES								
2.2.9.1	4"-20 Ga 16" o.c.metal studs for interior walls	2,451	sf	$0.70	$1.00	$1.70	$1,719	$2,441	$4,160
2.2.9.2	8"-20 Ga 16" o.c.metal studs for interior walls	1,956	sf	$1.38	$2.62	$4.00	$2,699	$5,125	$7,825
2.2.9.3	1/2" resilient channel for walls	839	sf	$0.29	$2.46	$2.75	$241	$2,067	$2,308
2.2.9.4	accoustical ceiling tile w/ suspension system	896	sf	$2.07	$1.68	$3.75	$1,855	$1,503	$3,357
2.2.9.5	gypboard for walls 1/2" taped & finished	4,884	sf	$0.28	$0.89	$1.17	$1,348	$4,351	$5,699
2.2.9.6	ceramic tile for bathroom walls 2x2 porcelein	702	sf	$4.60	$3.42	$8.02	$3,229	$2,399	$5,628
2.2.9.7	tile flooring for bathrooms	497	sf	$4.60	$3.42	$8.02	$2,287	$1,669	$3,986
2.2.9.8	tile flooring for seating/circulation areas 12x12	3,390	sf	$4.03	$2.16	$6.18	$13,645	$7,308	$20,953
2.2.9.9	vinyl tile for floor af cash room 12x12 VCT	24	sf	$1.12	$0.65	$1.77	$27	$16	$42
2.2.9.10	carpet-commercial grade, no pad 18" tile 20 oz	115	sy	$18.52	$2.16	$20.67	$2,126	$248	$2,374
2.2.9.11	painting-latex on drywall 2 coats spray	4,884	sf	$0.10	$0.22	$0.32	$488	$1,076	$1,564
2.2.9.12	painting-acrylic urethane on beadboard 2 coats brush	13,082	sf	$0.15	$0.44	$0.59	$1,962	$5,764	$7,727
2.2.9.13	painting-window frames	161	ea	$0.61	$39.66	$40.27	$98	$6,385	$6,483
2.2.9.14	painting-doors & frames	25	ea	$1.79	$58.75	$60.55	$45	$1,469	$1,514
2.2.9.15	painting-interior window sills	1,234	lf	$0.16	$0.44	$0.60	$199	$544	$743
2.2.9.16	painting-exterior window sills	673	lf	$0.16	$0.53	$0.69	$108	$356	$464
2.2.9.17	painting-trim	7,741	lf	$0.16	$0.53	$0.69	$1,246	$4,094	$5,340
	SUBTOTAL: FINISHES						$33,324	$46,843	$80,167
2.2.10	SPECIALTES								
2.2.10.1	10' handicap toilet partition plastic laminate cubical	1	ea	$747.50	$157.22	$904.72	$748	$157	$905
2.2.10.2	5' regular toilet partition	4	ea	$373.75	$78.61	$452.36	$1,495	$314	$1,809
2.2.10.3	11.5' handicap toilet partition	1	ea	$920.00	$104.81	$1,024.81	$920	$105	$1,025
2.2.10.4	toilet paper dispenser	7	ea	$11.50	$13.99	$25.49	$81	$98	$178

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.10.5	sanitary napkin dispenser	1	ea	$414.00	$27.93	$441.93	$414	$28	$442
2.2.10.6	paper towl sispenser	3	ea	$47.15	$26.20	$73.35	$141	$79	$220
2.2.10.7	soap sispenser	5	ea	$46.00	$26.20	$72.20	$230	$131	$361
2.2.10.8	3.5'x1' mirror in womens and mens bathroom	4	ea	$187.45	$27.93	$215.38	$750	$112	$862
2.2.10.9	3.5'x5' mirror in womens and mens bathroom	2	ea	$690.00	$104.81	$794.81	$1,380	$210	$1,590
2.2.10.10	3.5x2' mirror in toilet room	1	ea	$187.45	$27.93	$215.38	$187	$28	$215
2.2.10.11	clocks-interior	2	ea	$2,500.00		$2,500.00	$5,000		$5,000
2.2.10.12	clocks-stair tower	2	ea	$7,500.00		$7,500.00	$15,000		$15,000
2.2.10.13	marble countertop in womens and mens bathroom	16	lf	$200.00	$26.20	$226.20	$3,200	$419	$3,619
2.2.10.14	13'x2' interior sign	14	ea	$460.00	$104.81	$564.81	$6,440	$1,467	$7,907
	SUBTOTAL: SPECIALTIES						$35,986	$3,148	$39,134
2.2.11	FURNISHINGS								
2.2.11.1	oval wooden benches in seating/circulation area	3	ea	$1,800.00	$419.26	$2,219.26	$5,400	$1,258	$6,658
2.2.11.2	airport type seating in seating area	22	ea	$345.00	$52.41	$397.41	$7,590	$1,153	$8,743
2.2.11.3	end tables in seating area	5	ea	$414.00	$104.81	$518.81	$2,070	$524	$2,594
	SUBTOTAL: FURNISHINGS						$15,060	$2,935	$17,995
2.2.12	CONVEYING SYSTEMS								
2.2.12.1	elevator-pitless hydraulic, 2-story, completely installed	1	ea	$57,500.00		$57,500.00	$57,500		$57,500
	SUBTOTAL: CONVEYING SYSTEMS						$57,500		$57,500
2.2.13	PLUMBING/FIRE PROTECTION								
2.2.13.1	2" ball valve	3	ea	$40.25	$39.01	$79.26	$121	$117	$238
2.2.13.2	1" ball valve	6	ea	$14.95	$26.01	$40.96	$90	$156	$246
2.2.13.3	1-1/2"ball valve	4	ea	$31.05	$31.73	$62.78	$124	$127	$251
2.2.13.4	2" hard copper tubing for cold water, type L	110	lf	$16.68	$20.80	$37.48	$1,834	$2,288	$4,123
2.2.13.5	1" hard copper tubing for cold water, type L	175	lf	$6.33	$11.96	$18.29	$1,107	$2,093	$3,200
2.2.13.6	1-1/2" hard copper tubing for cold water, type L	80	lf	$10.93	$16.64	$27.57	$874	$1,331	$2,205
2.2.13.7	1/2" hard copper tubing for cold water, type L	190	lf	$3.45	$10.40	$13.85	$656	$1,976	$2,632
2.2.13.8	4" hub and spigot, cast iron soil pipe, sanitary system, below slab	150	lf	$19.09	$31.21	$50.30	$2,864	$4,681	$7,545
2.2.13.9	6" hub and spigot, cast iron soil pipe, sanitary system, below slab	110	lf	$28.41	$33.29	$61.69	$3,125	$3,662	$6,786
2.2.13.10	3" hub and spigot, cast iron soil pipe, sanitary system, below slab	140	lf	$13.57	$28.61	$42.18	$1,900	$4,005	$5,905
2.2.13.11	2" hub and spigot, cast iron soil pipe, vent system	100	lf	$11.73	$24.97	$36.70	$1,173	$2,497	$3,670
2.2.13.12	3" hub and spigot, cast iron soil pipe, vent system	150	lf	$15.53	$26.01	$41.53	$2,329	$3,901	$6,230
2.2.13.13	backflow preventor	2	ea	$971.75	$104.02	$1,075.77	$1,944	$208	$2,152
2.2.13.14	water meter	1	ea	$741.75	$104.02	$845.77	$742	$104	$846
2.2.13.15	wall hung urinals	2	ea	$661.25	$624.13	$1,285.38	$1,323	$1,248	$2,571

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.13.16	wall hung sink, 20"x18"	4	ea	$316.25	$520.11	$836.36	$1,265	$2,080	$3,345
2.2.13.17	wall hung toilets	7	ea	$920.00	$624.13	$1,544.13	$6,440	$4,369	$10,809
2.2.13.18	wall hung sink, single, in toilet room	1	ea	$316.25	$520.11	$836.36	$316	$520	$836
2.2.13.19	wall hung sink, single, in janitors closet	1	ea	$460.00	$520.00	$980.11	$460	$520	$980
	SUBTOTAL: PLUMBING/FIRE PROTECTION						$28,684	$35,885	$64,589
2.2.14	HVAC								
2.2.14.1	ductwork, 20 gauge	3,376	lb	$0.51	$4.46	$4.97	$1,708	$15,071	$16,779
2.2.14.2	12" round ductwork	242	lb	$0.51	$4.46	$4.97	$122	$1,078	$1,201
2.2.14.3	insulation for ductwork, 1" thick with vinyl jacket	1,125	sf	$0.30	$2.36	$2.66	$336	$2,656	$2,993
2.2.14.4	insulation for round ductwork, 1" thick with vinyl jacket	81	sf	$0.30	$2.36	$2.66	$24	$190	$214
2.2.14.5	10 ton condensor unit	1	ea	$2,156.25	$615.81	$2,772.06	$2,156	$616	$2,772
2.2.14.6	7.5 ton condensor unit	1	ea	$2,012.50	$461.86	$2,474.36	$2,013	$462	$2,474
2.2.14.7	fire dampers, 18"x16"	8	ea	$32.20	$25.66	$57.86	$258	$205	$463
2.2.14.8	volume diffusers, 24"x24"	26	ea	$118.45	$46.19	$164.64	$3,080	$1,201	$4,281
2.2.14.9	3/4" refrigeration lines with insulation in underground trench	22	lf	$8.05	$10.26	$18.31	$177	$226	$403
2.2.14.10	6 gallon electric water heater	1	ea	$345.00	$205.27	$550.27	$345	$205	$550
2.2.14.11	1.5 gallon electric water heater	2	ea	$287.50	$153.95	$441.45	$575	$308	$883
2.2.14.12	8" chimney	32	lf	$21.00	$51.32	$72.32	$672	$1,642	$2,314
2.2.14.13	3360 CFM furnace/coil combination unit	1	ea	$6,900.00	$1,231.62	$8,131.62	$6,900	$1,232	$8,132
2.2.14.14	2080 CFM furnace/coil combination unit	1	ea	$5,700.00	$1,026.35	$6,726.35	$5,700	$1,026	$6,726
2.2.14.15	5.3 MBH electric unit heaters	1	ea	$345.00	$153.95	$498.95	$345	$154	$499
2.2.14.16	4.1 MBH electric unit heaters	1	ea	$345.00	$153.95	$498.95	$345	$154	$499
2.2.14.17	600 CFM exhaust fan	1	ea	$805.00	$359.22	$1,164.22	$805	$359	$1,164
2.2.14.18	75 CFM exhaust fan	1	ea	$172.50	$51.32	$223.82	$173	$51	$224
2.2.14.19	300 CFM exhaust fan	1	ea	$207.00	$102.64	$309.64	$207	$103	$310
2.2.14.20	100 CFM exhaust fan	1	ea	$172.50	$51.32	$223.82	$173	$51	$224
2.2.14.21	400 CFM exhaust fan	2	ea	$207.00	$102.64	$309.64	$414	$205	$619
2.2.14.22	door air curtains	4	ea	$1,380.00	$1,231.62	$2,611.62	$5,520	$4,926	$10,446
2.2.14.23	ceiling diffuser, 24"x24"	20	ea	$218.50	$58.66	$277.16	$4,370	$1,173	$5,543
2.2.14.24	3'x1' wall louver	1	ea	$46.00	$25.66	$71.66	$46	$26	$72
2.2.14.25	400 CFM wall louver	3	ea	$46.00	$25.66	$71.66	$138	$77	$215
2.2.14.26	wall supply/ return registers, 18"x8'	5	ea	$34.50	$25.66	$60.16	$173	$128	$301
	SUBTOTAL: HVAC						$36,773	$33,527	$70,300
2.2.15	FIRE PROTECTION								
2.2.15.1	fire protection-wet sprinkler system	8,302	sf	$2.73		$2.73	$22,627		$22,627
	SUBTOTAL: FIRE PROTECTION						$22,627		$22,627

ITEM	DESCRIPTION OF COST ELEMENTS	QUANTITY	UNIT	UNIT COST			TOTAL COST		
				MATERIAL	LABOR	TOTAL	MATERIAL	LABOR	TOTAL
2.2.16	ELECTRICAL								
2.2.16.1	HVAC power distribution panelboard	1	ls	$4,150.00		$4,150.00	$4,150		$4,150
2.2.16.2	30kVA distribution transformer-station power and lighting	1	ls	$2,063.00		$2,063.00	$2,063		$2,063
2.2.16.3	225A station power and lighting panelboard	1	ls	$4,270.00		$4,270.00	$4,270		$4,270
2.2.16.4	tenant panelboard transformer and meters (4)	1	ls	$7,300.00		$7,300.00	$7,300		$7,300
2.2.16.5	tenant panelboard transformer and meters (4)	1	ls	$9,400.00		$9,400.00	$9,400		$9,400
2.2.16.6	track heater power distribution panelboard	0	ls	$5,324.00		$5,324.00			
2.2.16.7	parking area and lighting panelboard	1	ls	$3,265.00		$3,265.00	$3,265		$3,265
2.2.16.8	exhaust fan-including wiring	1	ls	$6,037.00		$6,037.00	$6,037		$6,037
2.2.16.9	cabinet heater-including wiring and terminations	1	ls	$4,512.00		$4,512.00	$4,512		$4,512
2.2.16.10	electric service for air conditioning unit	1	ls	$1,013.00		$1,013.00	$1,013		$1,013
2.2.16.11	electric service for hot water pump	1	ls	$3,153.00		$3,153.00	$3,153		$3,153
2.2.16.12	electric service for electric door-south, east, north, and west vestibules	1	ls	$1,100.00		$1,100.00	$1,100		$1,100
2.2.16.13	illuminated signage	1	ls	$825.00		$825.00	$825		$825
2.2.16.14	station building-grounding subgrade	1	ls	$1,575.00		$1,575.00	$1,575		$1,575
2.2.16.15	metering switch board	1	ls	$11,100.00	$1,080.00	$12,180.00	$11,100	$1,080	$12,180
2.2.16.16	equipment grounding (to be reviewed)	1	ls	$930.00		$930.00	$930		$930
2.2.16.17	electric service	1	ls	$2,000.00	$1,920.00	$3,920.00	$2,000	$1,920	$3,920
2.2.16.18	hanging pendant lights-main lobby and seating area	7	ea	$500.00	$204.00	$704.00	$3,500	$1,428	$4,928
2.2.16.19	2x2 flourescent lights with grid	20	ea	$200.00	$120.00	$320.00	$4,000	$2,400	$6,400
2.2.16.20	perforated pendant flourescent light on mezzanine	16	ea	$150.00	$96.00	$246.00	$2,400	$1,536	$3,936
2.2.16.21	surface mounted ceiling fixtures under eaves	26	ea	$120.00	$58.50	$178.50	$3,120	$1,521	$4,641
2.2.16.22	wall sconces in lobby	16	ea	$85.00	$33.75	$118.75	$1,360	$540	$1,900
2.2.16.23	2x4 flourescent lights with grid	6	ea	$300.00	$146.25	$446.25	$1,800	$878	$2,678
2.2.16.24	conduit and wire allowance	1	ls	$5,000.00	$18,000.00	$23,000.00	$5,000	$18,000	$23,000
2.2.16.25	lighting allowance for emergency and exit lights	1	ls	$5,000.00	$2,700.00	$7,700.00	$5,000	$2,700	$7,700
2.2.16.26	communications system for building (telephone, public addree, etc.)	1	ls	$77,538.00		$77,538.00	$77,538		$77,538
2.2.16.27	fire alarm system for building (smoke detectors, annunciation panel, etc.)	1	ls	$20,000.00		$20,000.00	$20,000		$20,000
	SUBTOTAL: ELECTRICAL						$186,411	$32,003	$218,414
	SUBTOTAL: STATION BUILDING-SCHEME 1 (RECTANGULAR) NOT INCLUDING AFI						**$728,193**	**$405,807**	**$1,298,353**
	AFI @ 5% (Allowance for Indeterminents)						$36,410	$20,290	$64,918
	SUBTOTAL: STATION BUILDING - SCHEME 1 (RECTANGULAR) INCLUDING AFI						**$764,603**	**$426,097**	**$1,363,270**
	TOTAL: SITE SIDE CONSTRUCTION NOT INCLUDING AFI						**$2,996,574**	**$1,290,652**	**$4,451,579**
	TOTAL: SITE SIDE CONSTRUCTION INCLUDING AFI						**$3,146,403**	**$1,355,185**	**$4,674,158**

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Oct. 1998)

VALUE ENGINEERING
OPTIONS AT 60% FINAL DESIGN FOR
REDUCTION OF CONSTRUCTION COST

Option	Description	Recommended	Not Recommended
Sitework Options			
2.1.1	Adjust quantity for seeding along east side of daily lot	$41,900	
2.1.2	Adjust quantity/unit cost for concrete pavement in busway	$59,970	
2.1.3	Reduce the number of bollards protecting hydrants	$8,000	
2.1.4	Increase allowance for gas line installation	$16,900	
2.1.5	Add allowance for telephone line installation	$12,000	
2.1.6	Adjust the quantity/cost for concrete encasement of conduits on site	$44,825	
2.1.7	Defer construction of Local Bus canopy	$54,166	
2.1.8	Change from ornamental to chain link fence along main access road	$45,900	
2.1.9	Increase allowance for site signage	$10,000	
	Sitework Options	**$95,921**	
	Reduction in AFI	**$127,661**	
	Total Sitework Adjustment	**$223,582**	
Building Options			
2.2.1	Defer installation of stair tower clocks to future	$13,909	
2.2.2	Use less ornate clocks on mezzanine overlooking lobby	$4,400	
2.2.3	Add digital clock at Logan Express bus canopy and in bus waiting area	$800	
2.2.4	Eliminate beadboard trim on lobby wall above wainscoat height	$1,647	
2.2.5	Change handrail in stair tower from black steel with spindles to painted steel pipe	$2,901	
2.2.6	Modify exterior wall brick pattern to running bond below bench height	$1,106	
2.2.7	Delete overhead coiling grilles from Tenant fronts (make tenant responsible)	$9,957	
2.2.8	Eliminate vestibule on pedestrian bridge at Building entrance	$1,282	
2.2.9	Eliminate ceramic tile on treads of stairs in tower	$454	
2.2.10	Delete carpeting from security/communications room	$289	
2.2.11	Change flooring in bus waiting area from ceramic tile to carpeting	$1,513	
2.2.12	Change exterior wall (8" insulated CMU back-up to 6" metal studs, insulation, gypboard) interior wall (8" CMU to 6" metal studs w/gypboars)	$28,111	
2.2.13	Reduce number of ornamental brackets from 22 to 8	$15,155	
2.2.14	Reduce the width of eave overhang from 10' to 8'		$13,274
2.2.15	Delete small triangular windows from end wall of upper peak		$4,142
2.2.16	Change windows from vinyl clad wood to vinyl		$19,375
2.2.17	Replace bituthene membrane on roof with tar paper		$8,529
2.2.18	Replace copper flashing on roof with cap shingles		$4,223
2.2.19	Change toilet partitions to be stainless steel	$3,361	
2.2.20	Provide all new airport-type seating (not re-use/re-furbish Mishawum) for bus waiting		$12,583
2.2.21	Delete floor drains in main lobby floor	$2,274	
2.2.22	Revise electrical estimate	$17,688	
2.2.23	Relocate elevatore, encorporate stair tower into rectangular footprint		$27,641
	Building Options	**$96,525**	**$79,756**
	Reduction in AFI	**$24,918**	
	Total Building Adjustment	**$121,443**	**$79,756**
	Total Sitework plus Building Adjustments	**$345,025**	**$79,756**
	Estimated Cost for Site work and Building at 60%	**$4,674,158**	
	Options Recommended	**$345,025**	
		$4,329,133	

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, Dec. 1998)

Appendix F

FINAL DESIGN - 100% SUBMITTAL
ESTIMATE OF CONSTRUCTION COST

ITEM	DESCRIPTION OF COST ELEMENTS	TOTAL COST		
		MATERIAL	LABOR	TOTAL
2	SITE SIDE CONSTRUCTION			
2.1	SITEWORK			
2.1.1	Field Office	$18,000		$18,000
2.1.2	Utility Company Work to RTC Account	$48,400		$48,400
2.1.3	Earthwork, Embankment, Borrow	$290,868	$356,926	$647,794
2.1.4	Storm Drainage Systems	$21,286	$25,169	$56,455
2.1.5	Fencing, Guardrail, Bollards	$101,720	$52,610	$154,330
2.1.6	Sidewalk, Curbing, Paving	$826,298	$314,446	$1,140,743
2.1.7	Pavement Marking, Signage	$26,581	$33,989	$60,570
2.1.8	Sanitery Sewer System	$3,964	$11,278	$15,241
2.1.9	Water Distribution System	$61,847	$72,402	$134,249
2.1.10	Planting	$138,148		$138,148
2.1.11	Site Accessories	$113,961		$113,961
2.1.12	Concrete for Site Electrical	$66,367	$24,736	$91,102
2.1.13	Site Electrical (Filed Sub-Bid)	$311,138	$144,843	$455,980
2.1.14	Miscellaneous Site Structures	$89,103	$40,163	$129,266
2.1.15	Siteside Environmental Services		$24,000	$24,000
	SUBTOTAL: SITEWORK	**$2,117,700**	**$1,110,561**	**$3,228,261**
2.2	STATION BUILDING -(49'-8"X113-8"+TOWER)			
2.2.1	Earthwork	$2,486	$3,472	$5,958
2.2.2	Concrete	$31,092	$48,912	$80,005
2.2.3	Masonry (Filed Sub-Bid)	$30,043	$62,133	$92,176
2.2.4	Structural Steel	$85,937	$50,149	$136,086
2.2.5	Miscellaneous Steel and Ornamental Iron (Filed Sub-Bid)	$37,866	$22,103	$59,969
2.2.6	Wood and Plastic	$64,481	$60,149	$124,630
2.2.7	Thermal and Moisture Protection (Filed Sub-Bid)	$35,045	$26,141	$61,186
2.2.8	Doors and Windows (Filed Sub-Bid)	$57,730	$23,600	$81,330
2.2.9	Finishes (Filed Sub-Bid)	$30,982	$46,241	$77,224
2.2.10	Specialtes	$25,906	$7,945	$33,850
2.2.11	Furnishings	$7,050	$1,200	$8,250
2.2.12	Conveying Systems (Filed Sub-Bid)	$56,300		$56,300
2.2.13	Fire Protection	$34,572	$16,717	$51,289
2.2.14	Plumbing (Filed Sub-Bid)	$50,193	$32,298	$82,491
2.2.15	Heating, Ventilating and Air-Conditioning (Filed Sub-Bid)	$44,878	$51,397	$96,275
2.2.16	Electrical (Filed Sub-Bid)	$175,906	$19,698	$195,604
	SUBTOTAL: STATION BUILDING	**$770,467**	**$472,155**	**$1,242,622**
	TOTAL: SITE SIDE CONSTRUCTION	**$2,888,167**	**$1,582,715**	**$4,470,883**

(Source: Massport, *Regional Transportation Center*, Massport Project No. 1.727, April 1999)